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U.S. NAVY ENGINEERING FIELD ACTIVITY, NORTHEAST
REMEDIAL ACTION CONTRACT (RAC)
CONTRACT NO. N62472-99-D-0032
CONTRACT TASK ORDER NO. 0089

DRAFT CLOSEOUT REPORT FOR SITE 4 THERMAL TREATMENT REMEDIATION

NAVAL WEAPONS INDUSTRIAL RESERVE PLANT
BEDFORD, MASSACHUSETTS

April 26, 2005

Prepared by

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Revision	Date	Prepared by	Approved by	Pages Affected
0	4/26/05	Y. Zhang	J. Francis	All

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N62472-99-D-0032	**0089**	**Naval Weapons Industrial Reserve Plant - Bedford, MA**

PROJECT TITLE:
Thermal Treatment Pilot Test

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Tetra Tech EC, Inc.: Program QC Manager Thomas Kelly	April 26, 2005
TO: **T. Bober (CD-Copy)**	DATE April 26, 2005

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1	SD-18, Records; Draft Closeout Report for Site 4 Thermal Treatment Remediation	Amy Karaskevicus			

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LIST OF ACRONYMS AND ABBREVIATIONS

ASTM	American Society for Testing and Materials
bgs	below ground surface
BTEX	benzene, toluene, ethylbenzene, and xylene
°C	Degrees Celsius
CGI	Combustible Gas Indicator
COC	Contaminants of Concern
CPVC	chlorinated polyvinyl chloride
CTO	Contract Task Order
EFANE	Engineering Field Activity, Northeast
ENSR	ENSR International
ERH	Electrical Resistance Heating
°F	Degrees Fahrenheit
FID	Flame Ionization Detector
GAC	Granular Activated Carbon
Hg	Mercury
hp	horsepower
kW	kilowatt
lb	pound
LEL	lower explosive limit
MCL	maximum contaminant level
MCLG	maximum containment level goal
NWIRP	Naval Weapons Industrial Reserve Plant
O&M	Operation and Maintenance
PCU	Power Control Unit
PESM	Project Environmental and Safety Manager
PID	Photo Ionization Detector
ppb	parts per billion
PPE	personal protective equipment
ppmv	parts per million by volume
QA/QC	Quality Assurance/Quality Control
RAC	Remedial Action Contract
scfm	standard cubic feet per minute
SHSO	Site Health and Safety Officer
SHSP	Site-Specific Health and Safety Plan
SOP	Standard Operating Procedure
SVOC	Semi-Volatile Organic Compound
TCL	Target Compound List
TMP	Temperature Monitoring Point
TRS	Thermal Remediation Services, Inc.
TtEC	Tetra Tech EC, Inc.
ug/kg	micrograms per kilogram
ug/L	micrograms per liter
USDOT	United States Department of Transportation
USEPA	United States Environmental Protection Agency
VOC	Volatile Organic Compound
VR	Vapor Recovery

1.0 INTRODUCTION

Tetra Tech EC, Inc. (TtEC) has prepared this Closeout Report for Site 4 Thermal Treatment Remediation under Contract Task Order (CTO) Number 0089, United States Navy Engineering Field Activity, Northeast (EFANE) Remedial Action Contract (RAC) Number N62472-99-D-0032. This Closeout Report for Site 4 describes the activities associated with the utilization of Electrical Resistance Heating (ERH), a thermal treatment technology, for the remediation of groundwater at the Naval Weapons Industrial Reserve Plant (NWIRP) located in Bedford, Massachusetts (the Site). The thermal treatment remediation at Site 4 was performed to remove benzene, toluene, ethylbenzene, and xylene (BTEX) contamination in soil and groundwater in the defined area.

During the period of operation for Site 4 remediation, an ERH pilot test was also conducted simultaneously in a nearby area identified as Site 3 to determine the applicability of the thermal treatment technology for full-scale treatment of chlorinated solvents in the groundwater source area. Activities and project results pertinent to the Site 3 pilot test are included in *Draft Closeout Report for Site 3 Thermal Treatment Pilot Test, Naval Weapons Industrial Reserve Plant, Bedford, Massachusetts* (TtEC, April 2004), and will not be discussed in this Closeout Report for Site 4. Where appropriate, this Closeout Report for Site 4 may reference the Closeout Report for Site 3, or discuss results from joint operations between Site 3 and Site 4, including a combined vapor recovery (VR) and treatment system as well as a combined waste disposal system.

1.1 Site Background and History

The vicinity of NWIRP is depicted on Figure 1-1. The northern portion of the Site is located on Hartwells Hill. The northern slope of Hartwells Hill drops steeply at the northern-most property boundary, where the Site 4 thermal treatment project took place. Elm Brook and associated wetlands are present to the west and north of the facility, near the base of Hartwells Hill. A residential area and additional wetlands are located to the east and northeast. Other properties abutting the Site include Raytheon Missile Systems Division facilities to the west and Hanscom Field (formerly Hanscom Air Force Base) to the south.

Site 4 consisted of a subsurface source area and a dissolved-phase plume containing primarily BTEX constituents. The dissolved plume started at the source area near the former Transportation Building and migrated in a northwesterly direction across the Site and towards an off-site wetland area adjacent to Elm Brook (Figure 1-2). The date of the release that created this source area is not known, but it was due to the former presence of a 7,600-gallon underground storage tank which contained gasoline. This tank was removed by Raytheon between December 1988 and January 1989, along with some contaminated soil. Soil was not excavated beneath the building at that time in order to prevent any impacts to its structural integrity. Later groundwater sampling indicated levels of BTEX as high as 99,800 parts per billion (ppb) in MW-18S (1993). Between February 1997 and February 2000, the highest detected BTEX concentration in MW-18S was 56,300 ppb (1997). From November 2000 through January 2002, in situ chemical oxidation treatment was performed by GeoCleanse to reduce the mass of petroleum-related compounds in the source area. However, according to an investigation conducted in June 2002, the levels of BTEX in the groundwater of MW-18S still remained at above 20,000 ppb.

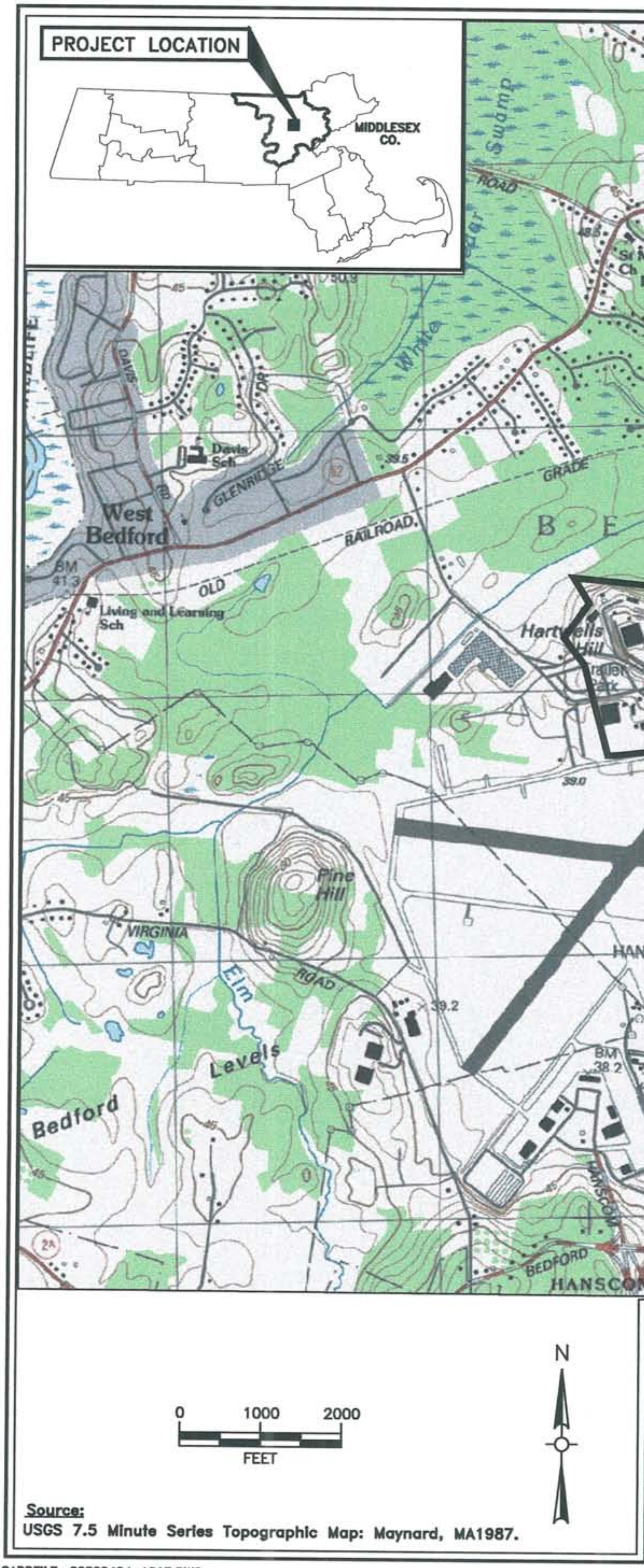

FIGURE 1-1

NAVAL WEAPONS INDUSTRIAL RESERVE PLANT (NWIRP)
BEDFORD, MASSACHUSETTS

SITE AREA MAP

SCALE: AS SHOWN

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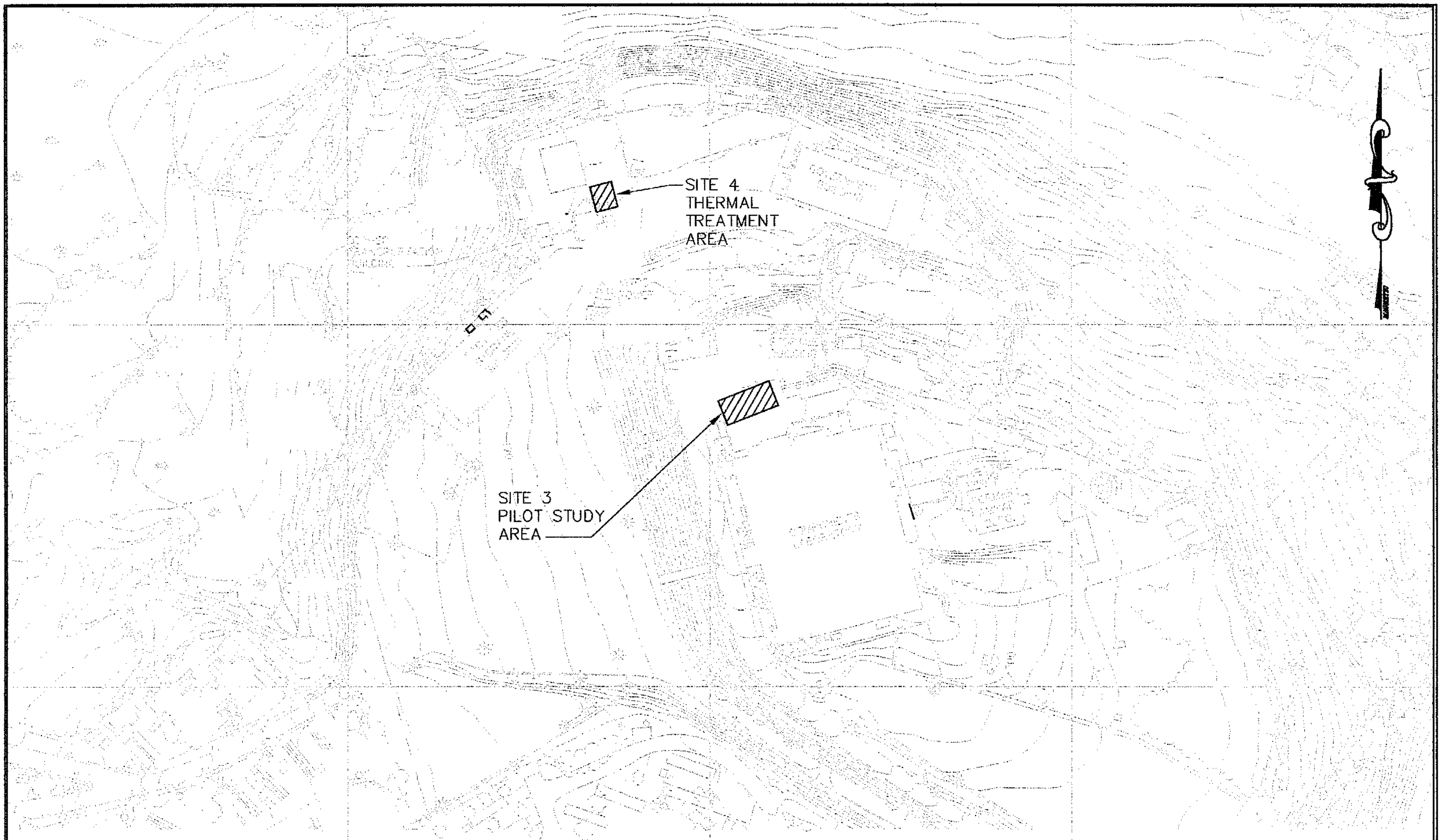

LEGEND

THREAD OF STREAM
FENCE
CONDUIT
GUARD RAIL
STONE WALL
TREE LINE
TREE OR SCHRUB
SEWER MANHOLE
DRAIN MANHOLE
UNDETERMINED MANHOLE
□ or ■ CATCH BASIN

UTILITY POLE
LIGHT POLE
UNKNOWN STRUCTURE (PROBABLE POST OR POLE)
WETLANDS

0 200 400
SCALE IN FEET

FIGURE 1-2

NAVAL WEAPONS INDUSTRIAL RESERVE PLANT
BEDFORD, MASSACHUSETTS

SITE PLAN

SCALE: AS SHOWN

CAD FILE: 22820424_A010.DWG

1.2 Overview of ERH Remediation Program

The general strategy of the ERH remediation program at Site 4 was to implement an in situ thermal treatment technology that heated the shallow and intermediate groundwater for a set period of time while collecting and treating volatile organic compound (VOC) laden vapors in a combined VR and granular activated carbon (GAC) adsorption system for Site 3 and Site 4. Monitoring of various parameters, such as energy inputs, soil temperature, induced vacuum, extracted vapor flow rates, extracted vapor concentrations, and pre-treatment, mid-process, post-treatment and long-term monitoring groundwater VOC concentrations were performed to provide measurements of effectiveness of the thermal treatment technology.

1.2.1 Project Team

The design, installation, and operation of the ERH thermal treatment system for the simultaneous Site 3 pilot test and Site 4 remediation were performed by Thermal Remediation Services, Inc. (TRS), an experienced ERH subcontractor that TtEC procured. The final report for the Site 4 remediation prepared by TRS is included in Appendix A of this Closeout Report for Site 4. ENSR International (ENSR), under subcontract to TtEC, was also part of the team for the completion of the Site 4 remediation. Table 1-1 provides a summary of the major roles and responsibilities of TtEC, TRS, and ENSR for the Site 4 thermal treatment remediation project.

Table 1-1
Summary of Roles and Responsibilities for the Site 4 Remediation

Task	TtEC	TRS	ENSR
Work Area and Treatment Location	Lead Role	N/A	Review Role
Design of ERH Wells and Layout	Review Role	Lead Role	N/A
Additional Monitoring Well Installation and Baseline Survey	Lead Role	N/A	Review Role
Pre-Treatment Groundwater Sampling	Co-Lead Role	N/A	Co-Lead Role
ERH System Design and Installation	Review Role; Supply power connection.	Lead Role	N/A
VR System Design and Installation	Review Role; Design and procure vapor collection system.	Lead Role	N/A
Vapor Treatment System Installation	Review role; Provide GAC vessels.	Lead Role (installation)	N/A
Thermal Treatment System Shakedown and Start-up	Review Role	Lead Role	N/A
Thermal Treatment System Operation and Maintenance (O&M)	Review Role	Lead Role	N/A
Thermal Treatment System Sampling	Lead Role	Review Role	N/A
Post-Treatment Performance Testing and System Monitoring	Lead Role	Review Role	Review Role
Long-term Monitoring Groundwater Sampling (Six months after heating)	Co-Lead Role	N/A	Co-Lead Role
Thermal Treatment Data Analysis and Final Reporting	Lead Role	Review Role	Review Role

1.2.2 Site 4 Thermal Treatment Remediation Objectives

The objective for Site 4 thermal treatment remediation was to significantly reduce the overall mass of petroleum-derived VOCs in the source area so that the remaining dissolved-phase plume could naturally attenuate to levels below the federal and state drinking water standards (maximum contaminant level (MCL) and non-zero maximum contaminant level goal (MCLG)) over time. Contaminants of concern (COCs) in the groundwater at Site 4 are BTEX compounds. Modeling of BTEX migration in groundwater of Site 4 indicated that achievement of a benzene concentration of 300 ppb in the groundwater source area by remediation would allow the remaining dissolved-phase plume to attenuate over time.

The groundwater benzene concentration was used as the key indicator of remediation performance at Site 4. This was based on the fact that benzene has the lowest federal and state drinking water standard (5 ppb) among the BTEX compounds. The remediation action objective for the Site 4 thermal treatment remediation was to achieve benzene concentration of 50 ppb in the Site 4 groundwater.

1.2.3 Site 4 Thermal Treatment Remediation Design Basis

The design of the Site 4 ERH remediation was based on several factors including treatment area and volume, site-specific geology and hydrogeology, and the project objective. The thermal treatment was performed in an area approximately 25 feet southeast of the Antenna Range Building. This area corresponded to the highest detected groundwater BTEX concentrations on Site 4.

The thermal treatment area at Site 4 was originally proposed to be 20 feet wide and 30 feet long. The actual treatment area was expanded from the original dimensions to 20 feet wide and 50 feet long after elevated BTEX concentrations were detected in an upstream monitoring well (MW-65S) during the pre-treatment groundwater sampling between May 29 and June 2, 2003. The proposed and actual Site 4 thermal treatment area is depicted in Figure 1-3.

The subsurface treatment interval of the ERH treatment area was from approximately 9.5 feet to 28 feet below ground surface (bgs), where contamination was largely present. The remediation area was approximately 20 feet wide by 50 feet long with a 9.5 feet to 28 feet bgs subsurface treatment interval, resulting in a treatment volume of 719 cubic yards. Eight electrodes with collocated VR wells were installed to a depth of 30 feet bgs (i.e., 2 feet beyond the treatment interval of 28 bgs). The electrode design allowed subsurface power application and VR to be performed simultaneously within each boring. Subsurface temperatures were measured at three temperature monitoring points (TMPs) located within the treatment area. The locations of the eight electrodes are also depicted in Figure 1-3.

Contaminants were removed from the vapor stream by four 1,000-pound (lb) GAC vessels. Condensate and recovered groundwater were treated using a single 30-gallon liquid GAC vessel and were either returned to the subsurface via drip lines installed in each electrode boring or were evaporated via the on-site condenser cooling tower.

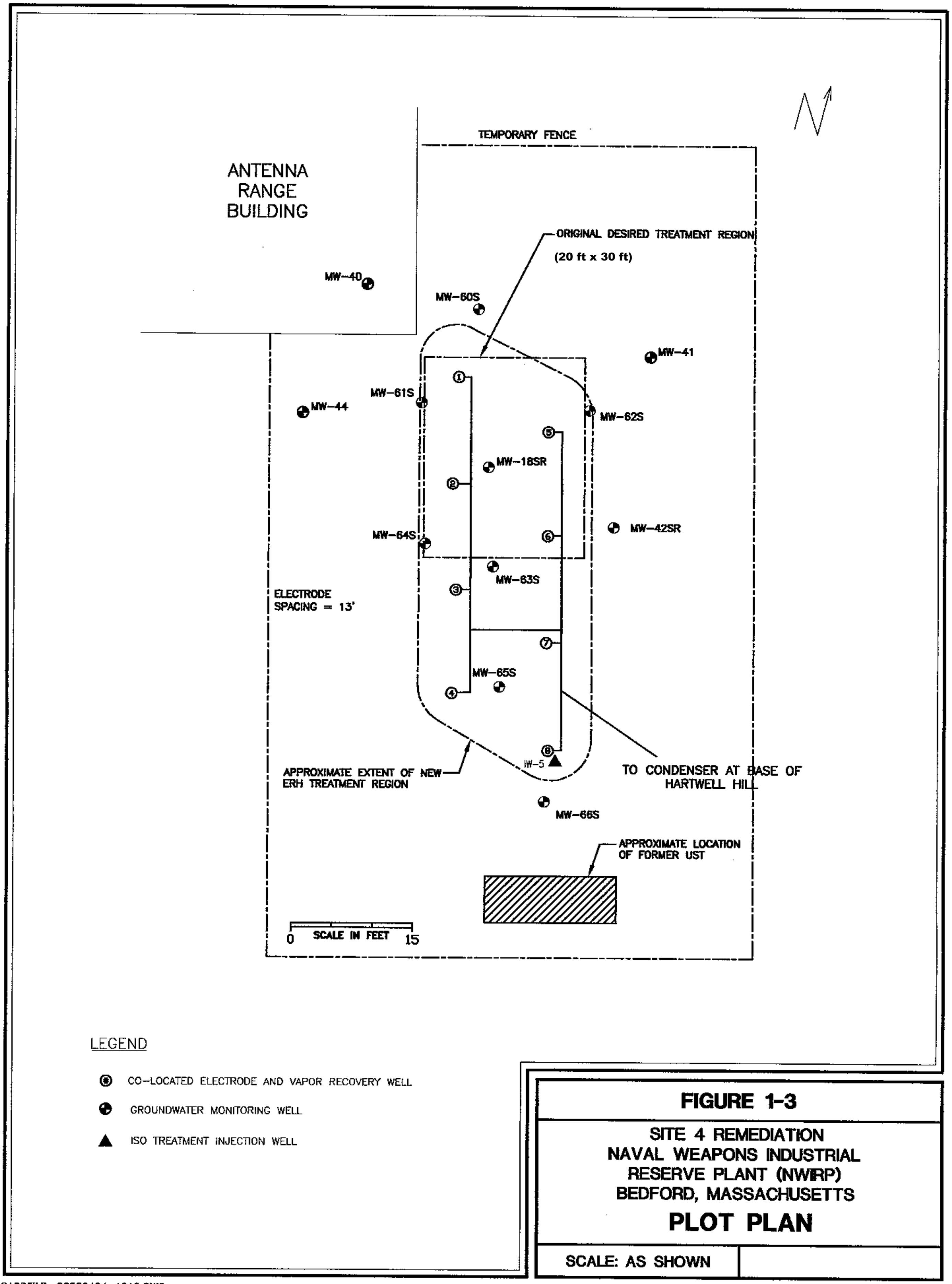

FIGURE 1-3

SITE 4 REMEDIATION
NAVAL WEAPONS INDUSTRIAL RESERVE PLANT (NWIRP)
BEDFORD, MASSACHUSETTS

PLOT PLAN

SCALE: AS SHOWN

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1.2.4 Site 4 Thermal Treatment Remediation Schedule

The actual field efforts for implementation of the Site 4 remediation were from groundwater monitoring well installation and pre-treatment soil characterization in May 2003 to the conclusion of temperature and groundwater level monitoring in August 2004. The following is a summary of the timeline for the completion of the Site 4 thermal treatment remediation activities:

- Groundwater monitoring well installation and pre-treatment soil sampling: May 14 to May 17, 2003; well installation and pre-treatment soil sampling for MW-66S were conducted on June 26, 2003.
- Pre-treatment groundwater sampling: May 29 to June 2, 2003; pre-treatment groundwater sampling for MW-66S was conducted on June 30, 2003.
- Mobilization of the ERH system components commenced on April 16, 2003. Additional equipment arrived between May 1, 2003 and July 30, 2003.
- Installation of the ERH system components started on May 14, 2003. Installation of the subsurface components ended on July 22, 2003, while installation of the above ground piping, wiring, and equipment was completed on July 29, 2003.
- The system start-up, shakedown, and testing occurred on July 30 and 31, 2003.
- Routine ERH system operations were performed over 53 days, from July 31, 2003 until September 22, 2003.
- Electrodes were shut off permanently on September 19, 2003.
- Mid-process groundwater sampling: September 9, 2003.
- Post-treatment groundwater sampling: September 29 - October 2, 2003.
- Final shutdown of the VR system occurred on October 9, 2003.
- Demobilization of the ERH system components and related supplies began on November 10, 2003. All system components were disassembled between November 10 and 14, 2003.
- Electrical power was disconnected from the power control unit (PCU) on December 19, 2003 and the office trailer was removed from the site on January 26, 2004.
- Long-term groundwater monitoring (6 months following the completion of the heating): August 2004.
- Temperature and groundwater level monitoring: May 2003 to August 2004.

1.2.5 Site 4 Thermal Treatment Remediation Data, Analysis, and Reporting

This Closeout Report for Site 4 presents data and information collected by TtEC, ENSR, and TRS. Data analysis has also been performed by TtEC, ENSR, and TRS with TtEC having the lead role in completing this Closeout Report for Site 4.

2.0 ERH REMEDIATION

The execution of the ERH remediation at Site 4 involved various distinct tasks beginning with pre-treatment characterization and ending with long-term groundwater monitoring. These tasks are described in the following sections and include:

- Pre-treatment soil and groundwater characterization.
- Installation and start-up.
- ERH operation.
- Mid-process groundwater characterization.
- Post-treatment groundwater characterization.
- Long-term groundwater monitoring.

The information contained in Section 2.2, Installation and Start-Up, and Section 2.3, ERH Operation, references TRS's final report contained in Appendix A. Additional detailed information regarding these subjects can be found within Appendix A. Sections 2.1, 2.4, 2.5, and 2.7, Pre-Treatment Soil and Groundwater Characterization, Mid-Process Groundwater Characterization, Post-Treatment Groundwater Characterization, and Long-Term Groundwater Monitoring, respectively, discuss data that were collected, validated, and reported by TtEC.

Appendix B includes photographic documentation of the Site 4 ERH Thermal Treatment Remediation.

2.1 Pre-Treatment Soil and Groundwater Characterization

Soil samples were collected during the installation of seven new groundwater monitoring wells. Groundwater samples were collected from the 1 existing, 2 replacement and 7 new monitoring wells prior to the initiation of the ERH remediation at Site 4. Soil and groundwater samples were sent to Woods Hole Group Laboratories, Raynham, MA for the analyses of Target Compound List (TCL) VOC using United States Environmental Protection Agency (USEPA) Method 8260B and 2-methylnaphthalene using USEPA Method 8270C. Analytical results for the pre-treatment samples were used to compare with the results for the groundwater samples collected during and after the treatment.

2.1.1 Pre-Treatment Soil Sampling

Monitoring well installations for MW-60S, MW-61S, MW-62S, MW-63S, MW-64S, and MW-65S were conducted between May 14 and 17, 2003, and the installation for MW-66S was performed on June 26, 2003. The monitoring well construction diagrams for the seven new groundwater monitoring wells and two replacement wells (MW-18SR and MW-42SR) are included in Appendix C.

Soil samples were collected by TtEC from the seven soil borings drilled for the new groundwater monitoring well installations in 5-foot long lexan liners using a rotosonic drilling rig. The sample tube was cut open at 6-inch intervals using a utility knife, and a potential sample location was selected in every 5-foot interval based on field Flame Ionization Detector (FID) readings and visual observations of the soil boring. The soil boring logs produced from the drilling and soil sampling activities for the seven soil borings are included in Appendix C. FID screening results for the soil borings were recorded in the boring logs under the column titled "FID." Figure 1-3 depicts final locations of the existing and newly-installed monitoring wells.

One soil sample was collected per soil boring for laboratory analysis, based upon the FID readings and visual observations. One grab sample was collected from each boring for TCL VOC analysis using openbarrel syringes and laboratory-preserved sample vials. One composite sample was also collected from each boring at the same interval as the VOC fraction for the analysis of semi-volatile organic compounds (SVOCs), particularly 2-methylnaphthalene. Samples were immediately placed in a cooler with ice following sampling. Sample collection was performed in accordance with procedures outlined in Standard Operating Procedure (SOP) 4 in the *Thermal Treatment Pilot Test and Remediation Quality Assurance/Quality Control (QA/QC) Plan, Naval Weapons Industrial Reserved Plant, Bedford, Massachusetts, Rev. 2* (QA/QC Plan) (Foster Wheeler, July 2003). Sampling activities were documented on the soil boring logs and in the site logbook.

2.1.2 Pre-Treatment Groundwater Sampling

Groundwater samples were collected by TtEC using low-flow methods derived from the USEPA Region I *Low Stress Purging and Sampling Procedure for the Collection of Ground Water Samples from Monitoring Wells*. The low-flow sampling procedures were outlined in SOP S-2 in the QA/QC Plan. Groundwater samples were collected from the seven newly-installed and two replacement groundwater monitoring wells as well as an existing injection well located within or adjacent to the thermal treatment area between May 29 and June 2, 2003, and on June 30, 2003. These monitoring well locations are shown in Figure 1-3. One sample was collected from each of the monitoring wells MW-18SR, MW-42SR, MW-61S, MW-62S, MW-63S, MW-64S, IW-5, and MW-66S. One sample and one duplicate were collected from MW-60S. In addition, MW-65S was sampled twice during the pre-treatment sampling on June 2 and June 30, 2003. A total of 12 samples were collected during the pre-treatment groundwater sampling at Site 4.

Prior to the sampling activities, a round of water level measurements was conducted. The water level data are included in Table 2-1. Wells were purged and sampled using peristaltic pumps, and samples were collected after purging and water quality parameters had stabilized according to the criteria outlined in SOPs S-1 and S-2 in the QA/QC Plan.

Groundwater samples were immediately placed in a cooler with ice following sampling. All purging and sampling details were recorded on well purge data forms and in the site logbook. The well purge data forms for the pre-treatment sampling are included in Appendix D.

Table 2-1
Pre-Treatment Groundwater Sampling
Well Water Level Readings

Well ID	Sample Date	Water Level (ft below Top of Carbon Steel Riser)
MW-18SR	5/29/03	16.52
MW-42SR	5/29/03	15.59
MW-60S	5/29/03	20.30
MW-61S	5/29/03	17.59
MW-62S	5/29/03	17.79
MW-63S	5/29/03	15.36
MW-64S	5/29/03	14.95
MW-65S	5/29/03, 6/30/03	11.25, 11.30
MW-66S	6/30/03	10.44

2.1.3 Pre-Treatment Soil Sample Results

Pre-treatment soil samples were analyzed by Woods Hole Group Laboratories, Raynham, MA for TCL VOCs using USEPA Method 8260B and SVOCs (2-methylnaphthalene only) using USEPA Method 8270C. Analytical results for individual TCL VOCs, total VOCs, total BTEX, and 2-methylnaphthalene for the soil samples are tabulated in Table E-1 in Appendix E.

As indicated in Table E-1 in Appendix E, petroleum-related compounds including ethylbenzene, naphthalene, toluene, p/m xylene, and o-xylene were detected in the soil samples collected from the soil borings for the seven newly-installed groundwater wells at Site 4. Among these compounds, p/m-xylene had the highest concentrations in the soil samples with the exception of MW-66S-SBA-062603 in which only ethylbenzene was positively-detected at a low concentration (40 micrograms per kilogram (ug/kg)). Benzene, one of the COC and the key indicator compound for this remediation effort, was not detected in any of the soil samples. The soil sample data collected during the pre-treatment sampling event are consistent with the site history of petroleum-related contamination.

Total VOC concentration was the lowest in MW-66S (40 ug/kg) that was located outside the treatment area. Total VOCs ranged from low to moderate levels in the monitoring wells on the periphery of the treatment area including MW-62S (1330 ug/kg), MW-64S (91,200 ug/kg), MW-61S (119,800 ug/kg), and MW-60S (146,100 ug/kg). Soil sample data demonstrated the highest contamination levels in wells inside the treatment area including MW-63S and MW-65S with total VOC concentrations at 435,000 ug/kg and 363,000 ug/kg respectively.

Soil sample results for 2-methylnaphthalene also ranged from the lowest concentration (non-detect) in MW-66S to the highest concentration (770 ug/kg) in MW-63S.

2.1.4 Pre-Treatment Groundwater Results

Groundwater samples collected during the pre-treatment groundwater sampling event were analyzed by Woods Hole Group Laboratories, Raynham, MA for TCL VOCs using USEPA Method 8260B and SVOCs (2-methylnaphthalene only) using USEPA Method 8270C. Table F-1 in Appendix F contains analytical results for individual TCL VOCs, total VOCs, total BTEX, and 2-methylnaphthalene for all the groundwater samples collected during the Site 4 thermal treatment remediation, including the pre-treatment groundwater sample results.

Groundwater results generally followed similar contaminant distribution trend as observed in the soil samples, with monitoring wells outside the treatment area demonstrating lower contamination than wells inside the treatment area, while total VOC concentrations in the wells on the periphery of the treatment area varying from low to high levels. As indicated in Table F-1 in Appendix F, pre-treatment total VOCs ranged from 522.3 micrograms per liter (ug/L) (MW-66S) to 20,999 ug/L (MW-65S); total BTEX ranged from 502 ug/L (MW-66S) to 20,070 ug/L (MW-65S); benzene ranged from 14 ug/L (MW-42SR) to 360 ug/L (MW-IW-5); and 2-methylnaphthalene ranged from 5.8 ug/L (MW-42SR) to 80 ug/L (MW-65S).

Table F-1 in Appendix F shows that compounds positively-detected with the highest concentrations were mostly petroleum-derived compounds such as benzene, ethylbenzene, naphthalene, toluene, p/m xylene and o-xylene, with p/m xylene demonstrating the highest concentrations in most samples. Common laboratory contaminants including 2-butanone and acetone were also reported in most of the samples at concentration levels lower than the petroleum-derived compounds. In addition, chlorinated VOCs including trichloroethene and vinyl chloride were also detected in some samples at low concentrations, probably as a result of the Site's connected groundwater table with Site 3, which is known for chlorinated

VOC contamination. In summary, the Site 4 pre-treatment groundwater results indicated that petroleum-derived VOCs composed the majority of the total VOCs in most samples. This is consistent with the results from previous investigations and the site history of contamination from petroleum products.

2.2 Installation and Start-Up

Mobilization of the ERH system components commenced on April 16, 2003 with the delivery of the PCU for ERH operations. Additional equipment arrived between May 1, 2003 and July 30, 2003. Installation of the ERH system components started on May 14, 2003 with initiation of the drilling program for subsurface component installation. Installation of the subsurface components ended on July 22, 2003, while installation of the above ground piping, wiring, and equipment was completed on July 29, 2003. The system start-up, shakedown, and testing occurred on July 30 and 31, 2003, subsequent to the complete process installation. Operations officially began on July 30, 2003 with start-up and shakedown. The Site 4 thermal treatment remediation utilized various types of equipment installed in both subsurface and above ground locations.

2.2.1 Subsurface Components

ERH subsurface components included the following:

- Eight electrode/VR wells were installed to 30 feet bgs (see Figure 1-3).

- Seven new groundwater monitoring wells were installed to varying depths, depending upon the groundwater table depth and FID field screening results. Two existing monitoring wells (MW-18S and MW-42S) were abandoned and replaced so their construction materials were compatible with subsurface heating. In particular, screened intervals were constructed of stainless steel while riser sections were constructed of carbon steel. Appendix C contains well construction diagrams and soil boring logs completed during well installation and drilling. Soil sampling performed during installation is discussed in Section 2.1.1.

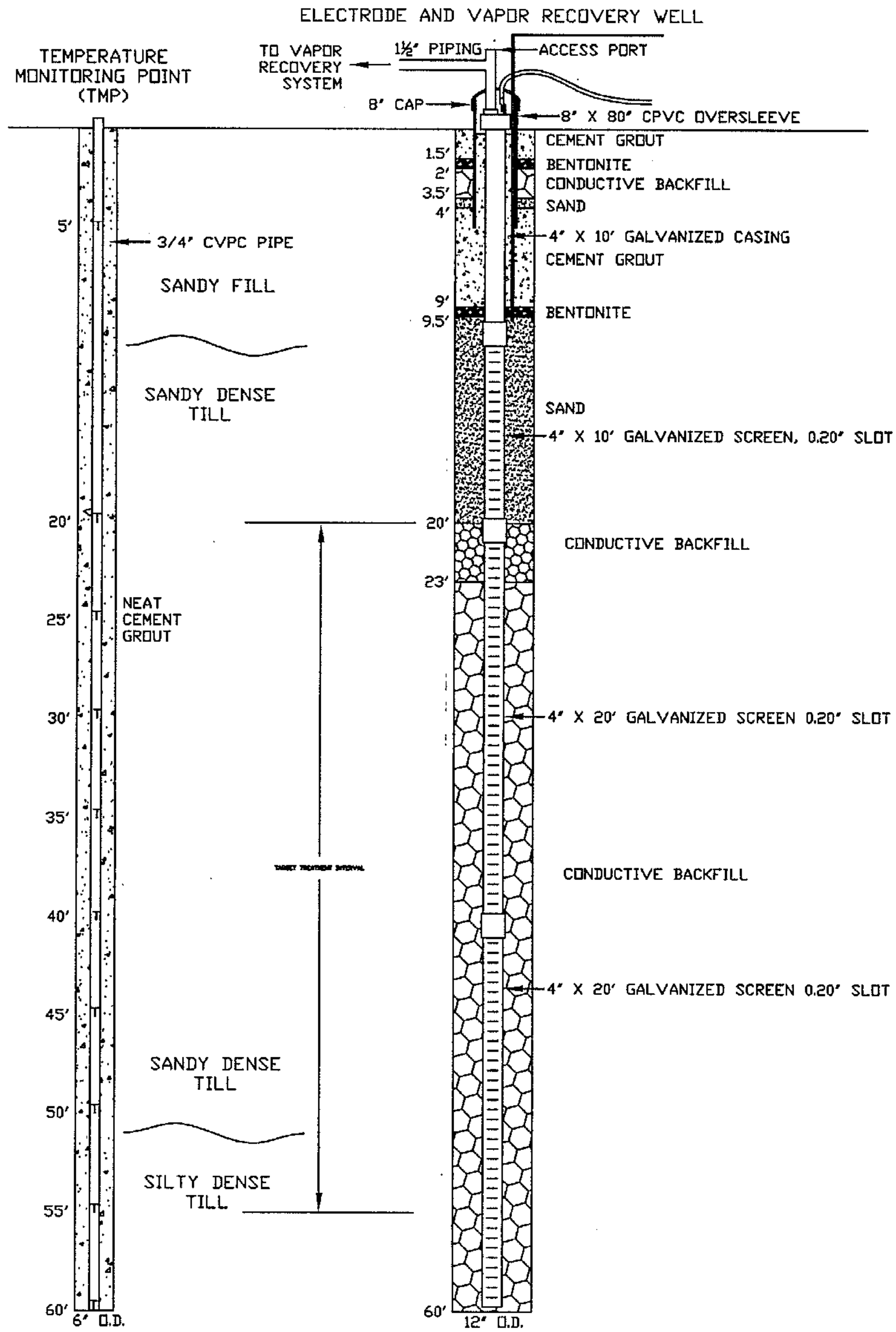
- Seven TMPs were installed concurrently with monitoring well installations. However, thermocouples were installed in only three of these TMPs.

Figure 2-1 provides a cross-section drawing of the electrode and TMP utilized during the Site 4 thermal treatment remediation.

2.2.2 Above Ground Components

During the subsurface installation, TRS installed the VR system, consisting of the VR manifold and above-surface process equipment, along with completing the piping and wiring connections to the electrodes and monitoring wells.

The heart of the ERH system was a PCU designed for 100% cycle duty and rated for a maximum power output of 2,000 kilowatts (kW). The VR manifold consisting of chlorinated polyvinyl chloride (CPVC) piping was connected from each VR well to the steam condenser that functioned to remove entrained liquids from the extraction process. The outlet of the steam condenser contains a knockout system that separates liquid from vapor phases. The condensate generated from the separated steam and groundwater passes through a liquid GAC treatment vessel and is used in the cooling loop to cool vapors and water removed during the VR process. Remaining condensate is recycled as electrode drip water and reinjected into the subsurface.



Source:
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FIGURE 2-1

NAVAL WEAPONS INDUSTRIAL RESERVE PLANT
BEDFORD, MASSACHUSETTS

ELECTRODE AND TMP CONSTRUCTION DETAILS

NOT TO SCALE

CADDFILE: 22820424-TRS-02.DWG

Air and vapor exiting the condenser skid following cooling was routed through vapor-phase GAC vessels to a VR blower unit, consisting of a 40 horsepower (hp) motor and vacuum pump capable of generating an original minimum of 6-inches of mercury (Hg) of vacuum. It had been re-sheaved soon after start-up in order to provide a range of 1-10-in Hg. Extracted hazardous vapors were treated using four 1,000-lb vapor-phase GAC vessels (provided by US Filter Westates) installed in a series-parallel configuration. Two parallel vessels served as the primary GAC vessel, while two others served as the secondary vessel. The GAC was provided and maintained by TtEC, including coordination of on-site changeouts.

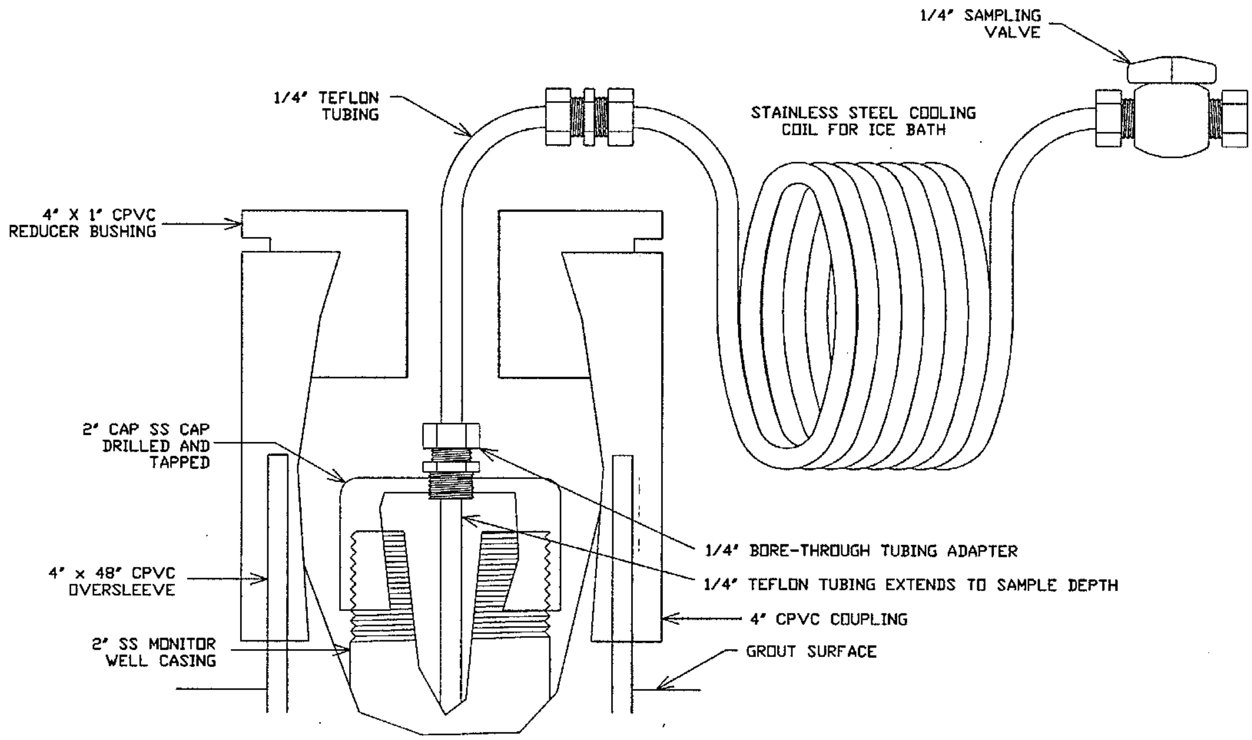
Groundwater monitoring well-heads for monitoring wells inside the ERH remediation area were modified for safety and sampling reasons, as seen in Figure 2-2. The capping of the well formed an enclosed system, where no gas or steam was allowed to escape from the top of the monitoring well. A stainless steel coil and valve were attached to the end of the groundwater sampling tubing, to be used during groundwater sampling. During sampling events, prior to purging a well, the coil was immersed in an ice water bath. The valve was opened and attached to a peristaltic pump. Sampling was progressed according to sampling procedures outlined in the QA/QC Plan. The coil apparatus functioned to enable the collection of cooled groundwater samples from heated groundwater without VOC losses.

<u>Instrumentation and Data Acquisition</u> - The data acquisition for the Site 4 thermal treatment remediation was performed by a combination of automatic and manual instrumentation. Much of the data was gathered through the control computer connected to the PCU. Temperature data from thermocouples installed in TMPs, in the vapor stream at the condenser influent and effluent, and at the blower stack, was routed to the computer system for the ability of automatic recording by TRS. Applied voltage to electrodes was able to be regulated and recorded by this PCU as well. Other operational data were able to be recorded on the PCU operations computer for use by TRS.

In order to determine energy input to individual electrodes, current surveys were to be performed using a clamping-type ampmeter. Various other instruments and gauges were available to collect data by TtEC personnel. Flow rates and temperatures of the vapor streams were to be measured through the use of an anemometer. Vacuum values, measured in inches of Hg were able to be measured through the use of vacuum gauges, of which several were available for various vacuum/pressure ranges. In addition, vapor samples were to be collected and screened using a Micro FID, MiniRAE Photo Ionization Detector (PID), and a VRAE Combustible Gas Indicator (CGI). Readings of the total cumulative volume of condensate generated during VR operations and the total volume reinjected into the subsurface as electrode drip water would be recorded as well, using permanently installed totalizers.

2.2.3 Start-up and System Shakedown

Start-up and system shakedown took place on July 30 and 31, 2003. TRS performed several tests and safety checks to ensure personnel safety during operations and successful working of the ERH system safety interlocks and emergency shutdowns. This work was in compliance with standard operating procedures as outlined in the *System Design and Work Plan, Electrical Resistance Heating Remediation Site 4, Naval Weapons Industrial Reserve Plant, Bedford, Massachusetts,* (TRS, April 2003).



Source:
©Thermal Remediation Services, 2002

FIGURE 2-2

NAVAL WEAPONS INDUSTRIAL RESERVE PLANT
BEDFORD, MASSACHUSETTS

MONITORING WELLHEAD DETAIL

SCALE: AS SHOWN

CADDFILE: 22820424-TRS-03.DWG

Additionally, during the first week of full operations, several changes were made to address other deficiencies found and to adjust for site-specific geologic and hydrogeologic conditions:

- As the site heated over the first few days (and became more conductive) the power input to the pilot test cell was at over 800 kW. This caused a high rate of increase in subsurface temperatures at an average of 5.2 degrees Celsius (^{o}C)/day and caused boiling near the electrodes at Site 3 only. This boiling led to mobilization of silt to the VR wells and, subsequently, the extracted vapor stream. Power application was reduced for both Sites 3 and 4, and later adjustments were made during operations.

- In order to lower the operating range for the vacuum provided by the blower, it was re-sheaved on August 12, 2003. The operating range was changed from a minimum of 6 in-Hg to having a range of 1-10 in-Hg. This adjustment was prompted by a need to have more control over the operating range of the blower, thus having the ability to lower steam (and groundwater) extraction rates.

- Excess water present in the cooling tower at Site 3 caused several operational shutdowns for both Sites 3 and 4 during the first week. Several causes of this were identified, and remedial measures were taken. See Section 2.2 of the Closeout Report for Site 3 for details regarding this adjustment.

2.2.4 Safety Considerations

- Although the Bedford NWIRP is surrounded by a barbed wire fence, temporary chain link fence with warning signs hung on it throughout its length was installed around the perimeter of the area to prevent unauthorized entry during unattended operations. This fence was installed to alleviate the requirement of 24-hour security during the test, and there were no unauthorized entries detected during the entire ERH operations.

- During the start-up period, stray voltage testing was conducted within and around the ERH treatment region to determine if any step-to-touch or step-to-step potentials existed. The testing and measures were taken to remove stray voltages, should any exist above the TRS safety limits of 30 volts for step-to-step potential and 15 volts for step-to-touch potential.

- Numerous system interlocks and safety systems exist within TRS's ERH equipment. These include water level switches and temperature interlocks for the steam condenser tank, cooling tower, and blower. Other safety systems and interlocks exist between system components, all of which were verified and checked during the start-up period. This testing was documented.

- During groundwater sampling events and any maintenance on electrodes or VR wells, the electrical power was turned off to the electrodes to prevent accidental contact with energized equipment. Power was then locked and tagged out by the personnel working on previously energized equipment. Additionally, when possible, the vapor extraction system was continuously kept in operation to prevent accumulation and/or fugitive emissions of steam and liberated vapors.

- Prior to entering the test area inside the perimeter fence for work-related reasons, any non-TRS employees were given a training session by TRS, detailing specific safety concerns and the means of eliminating any dangers to personnel. Additionally, specific activities were warned against, such as excavation or drilling near the area.

2.3 ERH Operation

2.3.1 Oversight Activities

During operations, TtEC was responsible for site management, project health and safety oversight and sampling/monitoring. A TtEC representative was on-site the majority of the time when any work was performed at the Site. For the greater part of the time spent on-site during Site 4 thermal treatment operations, one TtEC representative was present to perform these roles.

The Site Management role entailed monitoring, overseeing, and performing on-site observations/ inspection of work in progress to determine if the work was proceeding in accordance with the project QA/QC Plan. As part of this role, inspection and other quality-related reports were prepared and submitted. If any deficiencies on-site were found, the TtEC representative ensured resolution of these deficiencies and implemented any corrective action. This person also ensured that Site waste handling and manifesting were performed as required. The TtEC representative periodically reported to the Project Manager as to daily progress. The TtEC representative saw that all work performed by both TtEC and any subcontractors was completed in accordance with the *Final Work Plan For Site 4 Thermal Treatment, Naval Weapons Industrial Reserved Plant, Bedford, Massachusetts* (Work Plan) (Foster Wheeler, December 2003) and the QA/QC Plan.

In a related role, the TtEC representative served as the Site Health and Safety Officer (SHSO). The SHSO would ensure that all work on-site was being performed in accordance with the *Final Site -Specific Health and Safety Plan (SHSP) for Site 3 and Site 4 Thermal Treatment, Naval Weapons Industrial Reserved Plant, Bedford, Massachusetts* (Foster Wheeler, August 2003). Any operational changes that required modifications to health and safety procedures and the SHSP were identified, implemented, and documented by the SHSO. The SHSO maintained communication with both the Project Manager and the Project Environmental and Safety Manager (PESM) to ensure that the SHSP was being enforced for any TtEC employees and subcontractors and reported summaries of field operations.

TtEC personnel would also serve to perform monitoring of the ERH system components. This role is detailed in Section 2.3.4.

2.3.2 Description of Routine Operation

2.3.2.1 Electrode Operation

Routine operations were performed over 53 days, from July 31, 2003 until September 22, 2003.

Electrodes were shut off on August 12-13, 2003, for replacement of sheave on blower and repair to electrode water drip pump at Site 3. On August 14, 2003, a malfunction during a test of the PCU operating software caused a power and electrode shutdown that lasted approximately 20 hours until power was restored on August 15, 2003. In order to perform some cleaning of the VR system at Site 3, electrodes were turned off on August 19, 2003 for several hours. On August 20, 2003, for approximately four hours, on August 21, 2003 for approximately ten hours, and on August 27, 2003 for approximately

2.5 hours, electrodes were shut down for the addition of steel shot to VR wells at Site 3 for reduction of silting in the VR system.

During the week between September 1-6, 2003, electrodes were shut down for unknown amounts of time for addition of steel shot to VR wells at Site 4. During groundwater sampling on September 9, 2003 for approximately 7.5 hours, on September 10, 2003 for approximately eight hours, and on September 11, 2003 for approximately three hours, electrodes were turned off. A mid-process groundwater sampling round was conducted at Site 3 on September 18, 2003, when electrodes were turned off. Electrodes were shut off permanently on September 19, 2003, due to heat damage caused by a shut-off of the cooling water. Based on the mid-process groundwater sampling results for the monitoring wells at both Site 3 and Site 4, it had been determined that clean-up goals had been met, and therefore a decision was made to permanently leave off the electrodes. They were periodically turned off for other short periods throughout the thermal treatment operation in order to conduct both scheduled and unanticipated maintenance, as discussed in Section 2.3.3.

2.3.2.2 VR and Treatment System

The VR system was always in operation while electrodes were turned on, and during most times when electrodes were not turned on, as summarized in Section 2.3.2.1. The VR system did not operate during the power shutdown on August 14-15, 2003. Additionally, the shutdown on September 19, 2003 required repairs as described in Section 2.3.3.6. The VR system was restarted on October 2, 2003.

The majority of the problems associated with the ERH treatment were associated with the VR component. During the week of August 24-30, 2003, high power application rates to Site 4 electrodes began to occur, while boiling of the subsurface quickly took place immediately adjacent to electrodes. This caused very fine silts to become entrained in the boiling water and become transported into the recovered vapor stream, resulting in some problems as discussed in Section 2.3.3. While performing most maintenance activities, the vapor extraction system had remained operable.

An estimated total of 69.5 lbs of VOCs was removed from the subsurface at Site 4, as indicated in Table 2-2. Final shutdown of the VR system occurred on October 9, 2003.

2.3.2.3 Vapor Flow Rates and Vacuums

Throughout the duration of the vapor extraction system operation, several operational parameters and data values were recorded. The full list of these parameters is presented in Table 2-2. The influent vapor flow rate from Site 4 ranged from 24 to 183 standard cubic feet per minute (scfm). The vacuum on the Site 4 GAC influent ranged from 2 to 6.5 in-Hg. Section 2.3.4 describes the collection and use of the monitoring data gathered during the Site 4 remediation.

2.3.3 Description of Maintenance Activities

Throughout the course of the ERH operation, several maintenance issues occurred. The following summarizes these items, arranged according to the specific item of concern.

2.3.3.1 Excessive Water and Silt Recovery

High power and vacuum application rates became an issue during the week of August 24-30, 2003. High power caused boiling in the immediate vicinity of electrodes, which led to the introduction of silt into VR wells. Vacuum application was high enough to cause the extraction of this silt, along with groundwater and steam. Silt would subsequently enter the VR system and build up inside places such as the condenser unit. As a remedy to this extraction, on the week of September 1-6, 2003, steel shot was added to the inside of the eight 4-inch diameter VR wells up to the approximate measured depth of groundwater. The condenser unit and discharge system was cleaned of the silt deposits during this week as well.

Table 2-2
Sites 4 Operations Summary Data
ERH Thermal Treatment
Bedford NWIRP Site

			Primary GAC Inlet							Secondary GAC Inlet				GAC Effluent								
Date	Daily SVE Runtime (hours)	Cumulative SVE runtime (hours)	FID reading (ppmv)	PID reading (ppmv)	LEL reading (%)	Summa canister reading (ppmv)	Influent Temperature	Influent Vacuum (in. Hg)	Influent Vapor Flow (scfm)	FID reading (ppmv)	PID reading (ppmv)	LEL reading (%)	Influent Vacuum (in. Hg)	FID reading (ppmv)	PID reading (ppmv)	LEL reading (%)	Summa canister reading (ppmv)	Effluent Temperature (^{O}C)	Effluent Vacuum (in. Hg)	Effluent Vapor Flow (scfm)	VOC removed (lbs/day)	VOC removed (lbs cumulative)
31-Jul-03	14	14	9800	NM*	20	**14.8**	20.3	4.0	162	5510	NM*	21	4.0	5240	NM*	21	**0.028**	21.8	4.5	172	0.5	0.5
1-Aug-03	22.5	36.5	9800	NM*	20	14.8	20.3	4.0	162	5510	NM*	21	4.0	5240	NM*	21	0.028	21.8	4.5	172	0.9	1.4
2-Aug-03	24	60.5	9800	NM*	20	14.8	20.3	4.0	162	5510	NM*	21	4.0	5240	NM*	21	0.028	21.8	4.5	172	0.9	2.3
3-Aug-03	24	84.5	755	NM*	5	14.8	33.6	5.3	126	682	NM*	8	5.25	612	NM*	7	0.022	29.5	5.0	133	0.9	3.2
4-Aug-03	24	108.5	755	NM*	5	4.8	33.6	5.25	126	682	NM*	8	5.25	612	NM*	7	0.022	29.5	5.0	133	0.4	3.6
5-Aug-03	24	132.5	1585	NM*	8	4.8	37.2	6.5	71	1230	NM*	11	6.5	1233	NM*	10	0.022	34.0	5.5	152	0.2	3.8
6-Aug-03	24	156.5	836	NM*	5	4.8	34.6	5.5	144	718.0	NM*	10	5.5	707	NM*	8	0.022	30.9	5.5	127	0.4	4.2
7-Aug-03	24	180.5	515	NM*	6	**4.8**	33.2	5.0	137	445	NM*	8	5.25	452	NM*	11	**0.022**	32.5	5.5	155	0.4	4.6
8-Aug-03	24	204.5	2246	NM*	8	4.8	25.5	4.5	146	1733	NM*	9	4.75	1791	NM*	10	0.022	26.3	5.0	139	0.4	5.1
9-Aug-03	24	228.5	2246	41.9	8	4.8	25.5	4.5	146	1733	46	9	4.8	1791	31.2	10	0.022	26.3	5.0	139	0.4	5.5
10-Aug-03	24	252.5	389	41.9	3	4.8	28.3	5.5	143	328	46	7	5.5	280	31.2	4	0.022	29.6	5.5	147	0.4	6.0
11-Aug-03	24	276.5	389	41.9	3	3.8	28.3	5.5	143	328	46	7	5.5	280	31.2	4	0.053	29.6	5.5	147	0.2	6.2
12-Aug-03	21	297.5	288	64.5	1	3.8	31.6	5.5	160	239	105	4	5.25	216	97.4	2	0.053	28.7	5.5	158	0.2	6.4
13-Aug-03	20	317.5	990	54.9	4	3.8	31.5	3.2	127	374	2.5	4	3.8	505	27.1	3	0.053	30.0	4.0	143	0.2	6.5
14-Aug-03	14.5	332	591	4.7	5	**3.8**	41.1	6.0	137	509	0.3	8	5.8	414	0	5	**0.053**	34.0	4.0	215	0.1	6.7
15-Aug-03	14.5	346.5	591	4.7	5	3.8	41.1	6.0	137	509	0.3	8	5.8	414	0	5	0.053	34.0	4.0	215	0.1	6.8
16-Aug-03	24	370.5	591	4.7	5	3.8	41.1	6.0	137	509	0.3	8	5.8	414	0	5	0.053	34.0	4.0	215	0.1	6.9
17-Aug-03	23.5	394	316	189	4	3.8	23.2	2.5	159					217	21.6	4	0.053	25.6	3.0	186	0.2	7.0
18-Aug-03	24	418	316	189	4	3.8	23.2	2.5	159	258	88	4	2.5	217	21.6	4	0.053	25.6	3.0	186	0.2	7.3
19-Aug-03	16	434	324	1171	3	8.5	29.2	2.5	163	296	364	4	2.5	293	141	3	9.99	76.2	2.25	153	0.4	7.6
20-Aug-03	24	458	340	40.5	7	8.5	38.6	6.0	108	258	26	8	5.5	214	6.9	7	9.99	94.2	4.5	206	0.4	8.0
21-Aug-03	24	482	340	40.5	7	8.5	38.6	6.0	108	258	26	8	5.5	214	6.9	7	9.99	94.2	4.5	206	0.4	8.4
22-Aug-03	24	506	190	77.1	3	**8.5**	81.4	3.25	116	187	213	5	3.5	262	144	5	**9.99**	27.0	3.5	198	0.4	8.8
23-Aug-03	24	530	190	77.1	3	8.5	81.4	3.3	116	187	213	5	3.5	262	144	5	9.99	27.0	3.5	198	0.4	9.2
24-Aug-03	24	554	190	77.1	3	8.5	81.4	3.3	116	187	213	5	3.5	262	144	5	9.99	27.0	3.5	198	0.4	9.6
25-Aug-03	24	578	854	435	5	8.5	30.7	2.5	183	608	294	6	3	174	19.1	0	9.99	23.9	3	217	5.7	15.3
26-Aug-03	24	602	854	435	5	79.4	30.7	2.5	183	608	294	6	3.0	174	19.1	0	**18.52**	23.9	3.0	217	5.7	20.9
27-Aug-03	24	626	1275	960	12	79.4	32.6	3.5	113	574	460	12	4.0	465	147	10	**18.52**	28.2	4.0	180	3.5	24.4
28-Aug-03	24	650	4250	652	8	**79.4**	84.3	2.0	103	1364	169	7	3.0	939	55.1	5	**18.52**	28.2	3.0	256	3.2	27.6
29-Aug-03	24	674	4250	652	8	79.4	84.3	2.0	103	1364	169	7	3.0	939	55.1	5	18.52	28.2	3.0	256	3.2	30.8
30-Aug-03	24	698	4250	652	8	79.4	84.3	2.0	103	1364	169	7	3.0	939	55.1	5	18.52	28.2	3.0	256	3.2	34.0
31-Aug-03	24	722	4250	652	8	79.4	84.3	2.0	103	1364	169	7	3.0	939	55.1	5	18.52	28.2	3.0	256	3.2	37.2
1-Sep-03	24	746	2846	707	4	79.4	18.7	3.0	145	2216	480	5	3.5	1755	369	6	18.52	18.6	3.5	153	0.7	37.9
2-Sep-03	24	770	2846	707	4	12.4	18.7	3.0	145	2216	480	5	3.5	1755	369	6	0.213	18.6	3.5	153	0.7	38.6
3-Sep-03	14	784	2846	707	4	12.4	18.7	3.0	145	2216	480	5	3.5	1755	369	6	0.213	18.6	3.5	153	0.7	39.3
4-Sep-03	24	808	2846	707	4	12.4	18.7	3.0	145	2216	480	5	3.5	1755	369	6	0.213	18.6	3.5	153	0.7	40.0
5-Sep-03	17	825	1704	490	4	12.4	31.3	5.25	74	989	269	3	5.2	512	3.3	1	0.213	30.3	5.5	116	0.3	40.3
6-Sep-03	22.5	847.5	369	143	5	**12.4**	20.1	4.2	74	630	350	5	4.2	117	5.9	4	**0.213**	23.3	4.2	90	0.3	40.6
7-Sep-03	21.75	869.25	369	143	5	12.4		5.0	56	630	350	5	4.2	117	5.9	4	0.213	23.3	4.2	90	0.3	40.8
8-Sep-03	22.75	892	529	105	6	12.4	24.0	5.0	56	261	75	7	5.0	115	1.3	6	0.213	24.2	5.0	78	0.3	41.1
9-Sep-03	24	916	529	105	6	116.0		5.0	56	261	75	7	5.0	115	1.3	6	0.545	24.2	5.0	78	0.3	41.4
10-Sep-03	24	940	2236	467	12	116.0	12.5	2.25	24	323	52	6	2.5	265	0.9	6	0.545	14.4	3.25	86	0.3	41.7
11-Sep-03	24	964	1964	672	10	**116.0**	86.5	5.0	24	229	99.0	6	4.75	173	0.8	5	**0.545**	23.5	4.5	104	1.1	42.8
12-Sep-03	24	988	1550	406	10	116.0	19.9	4.0	33	298	107	3	4.25	226	3.0	4	0.545	23.9	4.5	79	1.5	44.3
13-Sep-03	24	1012	1550	406	10	116.0		4.0	33	298	107	3	4.3	226	3	4	0.545	23.9	4.5	79	1.5	45.8
14-Sep-03	24	1036	2750	467	6	116.0		5.5	33					403	32	5	0.545	30.9	5.5	110	1.5	47.3
15-Sep-03	24	1060	2750	467	6	116.0	28.7	5.50	33	531	120	6	5.5	403	32	5	0.545	30.9	5.5	110	1.5	48.8
16-Sep-03	24	1084	2750	413	16	116.0	85.9	5.25	33	531	150	10	5.5	403	47.2	8	0.545	29.6	5.5	96	1.5	50.2
17-Sep-03	24	1108	2750	413	16	116.0	85.9	5.25	33	531	150	10	5.5	403	47.2	8	0.545	29.6	5.5	96	1.5	51.7
18-Sep-03	24	1132	2750	413	16	116.0	85.9	5.25	33	531	150	10	5.5	403	47.2	8	0.545	29.6	5.5	96	1.5	53.2
19-Sep-03	24	1156	2750	413	16	116.0	85.9	5.25	33	531	150	10	5.5	403	47.2	8	0.545	29.6	5.5	96	1.5	54.7
20-Sep-03	24	1180	2750	413	16	116.0	85.9	5.25	33	531	150	10	5.5	403	47.2	8	0.545	29.6	5.5	96	1.5	56.2
21-Sep-03	24	1204	2750	413	16	116.0	85.9	5.25	33	531	150	10	5.5	403	47.2	8	0.545	29.6	5.5	96	1.5	57.7
22-Sep-03	11.5	1215.5	2750	413	16	116.0	85.9	5.25	33	531	150	10	5.5	403	47.2	8	0.545	29.6	5.5	96	0.7	58.4
2-Oct-03	10	1225.5	2750	413	16	116.0	85.9	5.25	33	531	150	10	5.5	403	47.2	8	0.545	29.6	5.5	96	0.6	59.1
3-Oct-03	24	1249.5	2750	413	16	116.0	85.9	5.25	33	531	150	10	5.5	403	47.2	8	0.545	29.6	5.5	96	1.5	60.5
4-Oct-03	24	1273.5	2750	413	16	116.0	85.9	5.25	33	531	150	10	5.5	403	47.2	8	0.545	29.6	5.5	96	1.5	62.0
5-Oct-03	24	1297.5	2750	413	16	116.0	85.9	5.25	33	531	150	10	5.5	403	47.2	8	0.545	29.6	5.5	96	1.5	63.5
6-Oct-03	24	1321.5	2750	413	16	116.0	85.9	5.25	33	531	150	10	5.5	403	47.2	8	0.545	29.6	5.5	96	1.5	65.0
7-Oct-03	24	1345.5	2750	413	16	116.0	85.9	5.25	33	531	150	10	5.5	403	47.2	8	0.545	29.6	5.5	96	1.5	66.5
8-Oct-03	24	1369.5	2750	413	16	116.0	85.9	5.25	33	531	150	10	5.5	403	47.2	8	0.545	29.6	5.5	96	1.5	68.0
9-Oct-03	24	1393.5	2750	413	16	116.0	85.9	5.25	33	531	150	10	5.5	403	47.2	8	0.545	29.6	5.5	96	1.5	69.5

Notes:
- Bold summa results represent actual sample data.
- Shaded rows represent days on which data was not collected. Data shown for these days was estimated based upon nearby days' data. Most days on which data was not collected was because site personnel were not on-site.
- Only summa canister data was used to calculate mass removed. No FID data was used.
- All data for 7/31/03, except for summa canister results, was estimated; it was only measured for a combined flow from Sites 3 and 4.
- FID readings on 9/16/03 were estimated.
- Vapor flow for Site 4 influent on 9/6/03, 9/10/03, and 9/15/03 was estimated due to moisture present in piping.
- NM* = Not measured. The use of PID was not initially planned upon but was later added beginning on 8/11/03.
- The ERH system was shut down from 9/23/03 through 10/1/03, due to an equipment failure. Cooling water was accidentally shut off, resulting in shutdown.
- The mass of VOCs = summa canister reading*influent vapor flow*concentration units conversion factor*mass units conversion factor*mass-weight conversion factor*volume units conversion factor*time units conversion factor.

2.3.3.2 PCU Auto Dialer

During the week of August 16, 2003, the remote access PCU software locked, preventing remote access to the PCU central computer. The lock-up appeared to be due to the auto dialer residing on the same telephone line as the PCU modem. To resolve this problem, the auto dialer was rerouted to use the telephone line that the site fax was using.

2.3.3.3 GAC Changeout

In order for the vapor-phase GAC treatment vessels to maintain a performance treatment standard for VOCs in the vapor stream, VOC concentrations prior to, between, and after the vessels was monitored three times per week during every week of operation. Breakthrough of the primary vessel was determined when the vessel's adsorption efficiency percentage was below 95% removal, at which time the GAC in that vessel was changed. This entailed removal of the spent carbon by means of a vacuum truck; the spent GAC was placed into supersacs for later disposal or regeneration. The secondary GAC vessels were then moved to serve as the primary vessels. New or reactivated GAC was added to the former primary vessels, which then became the secondary unit, by means of loading through the vessel manway on the top.

Due to silt infiltration issues into the VR system, the liquid GAC vessel became restricted. The vessel was cleaned, and the GAC within it was changed out on September 5, 2003. The used GAC was vacuumed out and placed into a 55-gallon drum for later disposal or regeneration.

2.3.3.4 Electrode Water Addition System

On September 6 or 7, 2003, the electrode water addition system was placed into a "hand" operational mode in order to avoid "high-high" level shutdowns. However, this action caused the cooling tower water to drain and moisture to condense in the VR lines. When these negative effects were realized, the electrode water addition system was placed back into an "automatic" operations mode.

2.3.3.5 Condenser System Shutdowns

In order to further address shutdowns that resulted from low or high water levels in the cooling tower and condenser system, on September 11, 2003, float levels in the cooling tower were adjusted. Additional changes were made to condenser system float levels on September 7-14, 2003. This adjustment provided more vertical difference between high and low water shut off levels, therefore decreasing the number of shutdowns that occur.

2.3.3.6 Loss of Make-Up Water

The TtEC site personnel inadvertently turned off the make-up water supply for the VR condenser and cooling tower on September 19, 2003. This resulted in a shutdown of power supply to the electrodes but system interlocks cycled between the on and off positions. Cooling water was lost, but VR progressed. Some damage was incurred by the CPVC vapor lines after the condenser system, and failure of piping occurred near the heat exchanger and between GAC vessels.

2.3.4 Summary of Monitoring Data

Through the use of general observation, flow meters, vacuum/pressure gauges, thermometers, water level gauges, volt meters, amp meters, FIDs, PIDs, and lower explosive limit (LEL) meters, data were acquired and recorded throughout the thermal treatment, from August 1, 2003 until September 16, 2003 on most of the days that the Site 4 remediation VR system was in operation. Most of these data were recorded by TtEC on a Daily Log Sheet that was sent to the Project Manager for review. See Table 2-2 for a summary of some of the daily monitoring data. Voltage data, current data, and thermocouple data were recorded by TRS and not included on Daily Log Sheets; these data were used as discussed in the TRS Final Report in Appendix A. System monitoring was performed in accordance with the project QA/QC Plan and Work Plan.

During the seven-week VR system operation, grab vapor samples were collected using summa canisters once every week from the separate inlet ports to the primary GAC units for Site 3 and Site 4 and from the combined GAC effluent. The sampling dates were: July 31, Aug. 7, Aug 14, Aug. 22, Aug. 28, Sept. 6, and Sept. 11. These vapor samples were sent to Air Toxics Ltd., Folsom, CA for analyses of TCL VOCs and methane using USEPA method TO-14A and American Society for Testing and Materials (ASTM) D-1946 respectively. All vapor samples were collected and analyzed in accordance with the project QA/QC Plan. Analytical data for the vapor samples collected from the Site 4 influent are summarized in Table G-1 in Appendix G, and data for samples collected from the combined effluent for Site 3 and Site 4 are summarized in Table G-2 in Appendix G.

The following sub-sections discuss results from these sampling and system monitoring activities.

2.3.4.1 Environmental Characteristics

FID readings from around the Site 4 perimeter fence were recorded on days during which a daily log was completed as health and safety screening data and were never higher than background values. In addition, an estimate of the precipitation that had accumulated for the previous 24-hour period was recorded; this data was recorded to potentially serve as justification for unusually high amounts of water being entrained by the VR system. The range of daily precipitation was from zero to 0.53 inches. All precipitation and ambient temperature data is shown in Table 2-3.

Visual observations were made daily. These include inspection of the electrode field to observe whether any steam or vapors were escaping from the tops of groundwater monitoring wells, VR wells, or from VR piping. The perimeter fences were observed to confirm that no unauthorized site entries had been attempted while the site was unattended.

2.3.4.2 Vapor Flow and Vacuum Data

Vapor flow on both the influent and effluent sides of the GAC vessels were measured using a portable electronic anenometer. The influent vapor flow was measured in the vapor stream pipe directly after the condenser unit, and the effluent flow was measured immediately after the secondary GAC vessel. The influent and effluent flow data are presented in Table 2-2. These data were used in conjunction with other data to calculate mass removal of VOCs, as discussed in Section 2.3.5 and Section 4.1.4 and calculated in Table 2-2. Site 4 influent vapor flow values ranged from 24 to 183 scfm, while the combined effluent flow values ranged from 78 to 256 scfm. Vacuum, measured in in-Hg, was monitored in the influent and effluent vapor streams at the same places that vapor flow was measured, and also in the vapor stream between the primary and secondary GAC units. Portable mechanical gauges were used to accomplish this. The influent and effluent vacuum data are included in Table 2-2. The influent vacuum measured in the vapor stream was between 2 and 6.5 in-Hg, while the GAC mid-point and effluent values ranged from 2.5 to 6.5 in-Hg and 2.25 to 5.5 in-Hg, respectively.

Note that mid-point and effluent vapor characteristics represent a combined vapor mass from the Site 3 pilot test and Site 4 remediation.

Table 2-3
Weather Conditions

Date	Temperature (degrees Fahrenheit (°F))			Precipitation (inches)	
	Average	Minimum	Maximum	Daily	Monthly
7/31/2003	69.0	57.0	81.0	0	NR[2]
8/1/2003	62.6	57.2	68.0	0.19	
8/2/2003	69.5	60.1	79.0	0.24	
8/3/2003	75.5	66.0	84.9	0.10	
8/4/2003	76.3	71.6	81.0	0.42	
8/5/2003	77.0	71.6	82.4	0.15	
8/6/2003	77	69.8	84.2	0	
8/7/2003	74.6	66.2	82.9	0.01	
8/8/2003	73.4	68.0	78.8	0.53	
8/9/2003	77.6	71.1	84.2	0	
8/10/2003	79.0	73.0	84.9	0.02	
8/11/2003	78.8	71.6	86.0	0	
8/12/2003	75.0	69.1	81.0	0.48	
8/13/2003	76.1	64.4	87.8	0	
8/14/2003	76.1	64.4	87.8	NA[1]	
8/15/2003	68.6	62.1	75.2	0	
8/16/2003	77.0	66.2	87.8	NA[1]	
8/17/2003	68.9	62.6	75.2	NA[1]	
8/18/2003	72.5	59.0	86.0	0.01	
8/19/2003	75.3	62.6	88.0	0	
8/20/2003	75.2	62.6	87.8	NA[1]	
8/21/2003	77.0	66.0	88.0	0	
8/22/2003	80.6	69.8	91.4	0.03	
8/23/2003	69.0	57.0	81.0	0.01	
8/24/2003	61.1	48.2	73.9	0	
8/25/2003	68.1	57.2	79.0	0	
8/26/2003	70.0	59.0	81.0	0	
8/27/2003	74.3	64.4	84.2	0	
8/28/2003	63.5	53.1	73.9	0	
8/29/2003	64.5	48.0	81.0	0	
8/30/2003	69.8	57.2	82.4	0	
8/31/2003	59.1	48.2	70.0	0	2.19
9/1/2003	62.5	57.0	68.0	0	
9/2/2003	62.0	57.0	66.9	0.31	
9/3/2003	63.6	57.2	70.0	0	
9/4/2003	64.0	60.1	68.0	0.04	
9/5/2003	67.0	57.0	77.0	0	
9/6/2003	62.6	50.0	75.2	0	
9/7/2003	64.5	50.0	79.0	0	
9/8/2003	62.6	51.8	73.4	0	
9/9/2003	55.8	44.6	66.9	0	
9/10/2003	55.7	37.4	73.9	0.01	
9/11/2003	64.0	51.1	77.0	0	
9/12/2003	61.7	51.8	71.6	0	
9/13/2003	62.2	51.1	73.4	0	
9/14/2003	71.6	62.6	80.6	0	

Table 2-3 – *cont'd*
Weather Conditions

Date	Temperature (degrees Fahrenheit (°F))			Precipitation (inches)	
	Average	Minimum	Maximum	Daily	Monthly
9/15/2003	67.0	57.0	77.0	0	
9/16/2003	67.1	57.2	77.0	NA[1]	
9/17/2003	66.5	59.0	73.9	0	
9/18/2003	60.8	48.2	73.4	NA[1]	
9/19/2003	59	66.5	73.9	NA[1]	
9/20/2003	72.5	62.6	82.4	0.04	
9/21/2003	63.5	53.1	73.9	0.01	
9/22/2003	61.9	51.8	72.0	0	0.41

Notes:
- Weather data obtained from www.wunderground.com, historical data for Bedford, Massachusetts.
- NA[1] Precipitation data for these dates was not available.
- NR[2] The ERH system only operated for one day this month; a monthly precipitation total was not necessary.
- The monthly precipitation total for September only represents that accumulated from September 1-22.

2.3.4.3 Temperature Values

The anenometer used to measure flow was also used to measure temperatures of influent and effluent vapors. Influent and effluent temperature values are presented in Table 2-2. Temperature values for the Site 4 influent vapor stream ranged from 12.5 to 86.5ºC; the effluent vapor stream displayed a range of 14.4 to 34.0°C. Temperature values recorded by thermocouples in TMPs and installed along VR piping were downloaded onto the PCU's computer system and retained by TRS for operational use. These values are discussed in the TRS Final Report in Appendix A.

2.3.4.4 Water/Condensate Levels and Amounts

Using sight glasses, water and condensate levels were measured in the condenser unit and cooling tower. A high or low level in any of these tanks could be due to any number of circumstances; however, certain levels would cause system shutdown. These levels were observed qualitatively by TRS for operational reasons and were not recorded.

Condensate/water amounts that had been extracted through the VR system were recorded to monitor whether unusually large amounts of water were being collected by the VR system. This data was collected using a totalizer after the condenser unit. The total value recorded at the end of the Site 4 remediation was over 8,500 gallons. The total volume of water that was re-injected into the treatment zone was over 1,200 gallons. The remaining water, approximately 7,300 gallons, was used as cooling water and had evaporated from the cooling tower during operations.

2.3.4.5 Blower and GAC Data

The system blower runtime represented the total VR system operating time, and a final estimated value of 1,393.5 hours was made.

Vacuum readings collected at the influent and effluent to each GAC unit were made and recorded as discussed in Section 2.3.4.2. FID, PID, and LEL readings were taken from Tedlar bags filled with air collected from the inlet ports on the primary and secondary GAC units and on the GAC outlet prior to air discharge at the blower stack. FID data were collected using a PE Photovac MicroFID, while PID data were collected using a MiniRAE 2000 PID. LEL was collected with a VRAE 7800 multi-gas meter. FID, PID, LEL, flow, and vacuum readings were obtained nearly daily from Monday through Friday during the ERH operation. FID, PID, and LEL data collected are summarized in Table 2-2.

Grab vapor samples were collected using Summa canisters once per week during the VR system operation, from the inlet port to the primary GAC unit and from the effluent of the GAC. The vapor sample data for the Site 4 influent and combined effluent are summarized in Tables G-1 and G-2 respectively in Appendix G. The total VOC values for the vapor samples are also presented in Table 2-2. During the seven summa canister collection events, the Site 4 influent values for total VOCs ranged from 4.8 to 116.0 parts per million by volume (ppmv) and the effluent values ranged from 0.022 to 18.52 ppmv.

2.3.5 Contaminant Removal Rate

Due to the poor correlation between the FID/PID readings and the laboratory results from the vapor sampling, VOC mass removal calculations were based on the data from the seven weekly vapor sampling events using Summa canisters. The Site 4 influent vapor analytical data, along with the Site 4 influent flow rate, vacuum, and temperature data, was used to calculate daily VOC mass removal amounts for the Site 4 thermal treatment remediation, as detailed in Table 2-2. Results for the Site 4 weekly influent samples were extrapolated to represent days when no grab vapor samples were collected.

Using the calculation presented in Table 2-2, it is estimated that the initial total VOC removal rate was approximately 0.5 lb/day on July 31, 2003. Due to fluctuations on the amount of vacuum employed on the well field, vapor flow, and influent vapor VOC concentration, the contaminant removal rates varied between 0.1 and 5.7 lb/day during the period of the VR system operation. The cumulative VOC removal during the Site 4 thermal treatment remediation was approximately 69.5 lbs.

2.4 Mid-Process Groundwater Characterization

2.4.1 Mid-Process Groundwater Sampling

To evaluate the on-going ERH process at Site 4 so that changes to the process could be made if required to optimize contaminant removal efficiency, mid-process groundwater samples were collected by TtEC on September 9, 2003 from monitoring wells MW-18SR, MW-63S, and MW-65S that were inside the thermal treatment area.

The mid-process groundwater samples were collected using a peristaltic pump in accordance with a modified version of the USEPA Region I low flow purging and sampling procedure (see SOP S-1/S-2 in Appendix C of the QA/QC Plan). Because of high sample temperature, special cooling procedures were adopted for the sampling using a peristaltic pump. When purging and sampling the well, the sampling valve on the wellhead was connected to a stainless steel cooling coil that was immersed in ice water. The outlet of the cooling coil was connected to the peristaltic pump. Using this technique, the hot groundwater was cooled. Groundwater wells were purged for more than an hour before the groundwater samples were collected. Sample bottles were placed in an iced cooler immediately upon filling.

Due to safety concerns, water levels of the wells were not measured during the mid-process groundwater sampling event. The water quality parameters were measured during the well purging. All sampling details were recorded on well purge data forms and in the site logbook. The well purge data forms are included in Appendix D.

2.4.2 Mid-Process Groundwater Analytical Results

Groundwater samples collected by TtEC from the mid-process sampling were sent to Woods Hole Group, Raynham, MA for TCL VOC analysis by USEPA Method 8260B. Tabulated analytical results for the mid-process groundwater samples are included in Table F-1 in Appendix F.

As indicated in Table F-1 in Appendix F, among the three monitoring wells that were sampled inside the treatment area during the mid-process sampling, total VOCs ranged from 226.1 ug/L (MW-18SR) to 5,488 ug/L (MW-65S), total BTEX ranged from 30.6 ug/L (MW-18SR) to 3,748 ug/L (MW-65S), and benzene ranged from non-detect (MW-18SR) to 14 ug/L (MW-65S). A comparison of the mid-process sample results with data from other sampling rounds will be discussed in Section 4.1.

2.5 Post-Treatment Groundwater Characterization

2.5.1 Post-Treatment Groundwater Sampling

The post-treatment groundwater sampling was conducted by TtEC after the ERH system was turned off and the groundwater temperature reached < 99^{o}C. During the post-treatment sampling event that occurred between September 29 and October 2, 2003, monitoring wells MW-18SR, MW-42SR, MW-60S, MW-61S, MW-62S, MW-63S, MW-64S, MW-65S, and MW-66S were sampled using a peristaltic pump.

Because of high sample temperature, special cooling procedures were adopted for the post-treatment groundwater sampling using a bladder pump. When purging and sampling the well, the sampling valve on the wellhead was connected to a stainless steel cooling coil that was immersed in ice water. The outlet of the cooling coil was connected to the bladder pump. Using this technique, the hot groundwater was cooled. Depending on its water level, a monitoring well was purged for 30 minutes or a minimum volume of water before the groundwater sample was collected. Sample bottles were placed in an iced cooler immediately upon filling.

The water quality parameters were measured during the well purging. All sampling details were recorded on well purge data forms and in the site logbook. The well purge data forms are included in Appendix D.

Post-treatment water levels in the monitoring wells were measured on September 29, 2003, as presented in Table 2-4.

Table 2-4
Post-Treatment Groundwater Sampling
Well Water Level Readings

Well ID	Sample Date	Water Level (ft below Top of Carbon Steel Riser)
MW-18SR	9/29/03	20.77
MW-42SR	9/29/03	20.35
MW-60S	9/29/03	22.86
MW-61S	9/29/03	21.18
MW-62S	9/29/03	22.01
MW-63S	9/29/03	20.24
MW-64S	9/29/03	19.85
MW-65S	9/29/03	18.39
MW-66S	9/29/03	13.60

2.5.2 Post-Treatment Groundwater Analytical Results

Post-treatment groundwater samples collected by TtEC were sent to Woods Hole Group, Raynham, MA for TCL VOC analysis by USEPA Method 8260B. Tabulated analytical results for the post-treatment groundwater samples are included in Table F-1 in Appendix F.

As indicated in Table F-1 in Appendix F, among the nine monitoring wells that were sampled during the post-treatment sampling, total VOCs ranged from 259.4 ug/L (MW-42SR) to 14,114 ug/L (MW-64S), total BTEX ranged from 138 ug/L (MW-63S) to 11,900 ug/L (MW-64S), and benzene ranged from non-detect (MW-63S) to 140 ug/L (MW-60S). A comparison of the post-treatment sample results with data from other sampling rounds will be discussed in Section 4.1.

2.6 Demobilization

Shut down of the electrodes occurred on September 22, 2003. For health and safety reasons, the VR system remained operable until October 9, 2003. Demobilization of the ERH system components and related supplies began on November 10, 2003, after authorization to shut down was given to the TtEC Site Manager by the Project Manager.

All system components were disassembled between November 10 and 14, 2003. Any reusable items owned by TRS were placed into temporary storage for shipment off-site. Expendable items and condenser units were decontaminated (when necessary) and placed into a trash dumpster. Any trailer-mounted or skid-mounted equipment, such as the condenser skid, PCU, and cooling tower will be removed in the near future by flatbed truck. Rental items such as the Baker excess condensate storage tank, helium tanks, and perimeter fence, were returned between these dates.

Spent vapor-phase GAC and vessels were removed from the site on November 12, 2003; the GAC was shipped for regeneration as hazardous waste. Spent liquid-phase GAC was removed from the site on November 19, 2003 and shipped for regeneration as non-hazardous waste. Liquid GAC vessels were purchased by TRS and will be removed with their other remaining equipment. These GAC shipments are detailed in Section 3.0. Roll-off dumpsters containing soil cuttings and personal protective equipment (PPE)/miscellaneous trash that had contacted soil and water were removed from the site between October 20-23, 2003. Ten dumpsters were shipped off-site as non-hazardous waste, and one was removed for asphalt batching on October 24, 2003, as detailed in Section 3.0.

Reuseable items that were purchased by TtEC during site work and may be used in the future were placed into the Antenna Range Building. Electrical power was disconnected from the PCU on December 19, 2003, and the office trailer was removed from the site on January 26, 2004.

The TMPs and electrodes remain installed, with CPVC oversleeves and drip tubing remaining intact for possible future full-scale ERH operations. Groundwater monitoring wells were capped as previously, and flush mount lids were replaced.

2.7 Long-Term Groundwater Monitoring

2.7.1 Long-Term Groundwater Sampling

A long-term groundwater monitoring event was conducted by TtEC between April 13 and 14, 2004, more than six months after the completion of the heating. The purpose of the long-term monitoring was to evaluate the long-term effectiveness of the thermal treatment remediation at Site 4 and obtain information on the geological and chemical processes of the groundwater system after the thermal treatment. The two replacement wells (MW-18SR and MW-42SR) and the seven newly-installed wells (MW-60S, MW-61S, MW-62S, MW-63S, MW-64S, MW-65S, and MW-66S) were sampled using a peristaltic pump. The long-term monitoring groundwater samples were collected using the same low-flow procedures as the pre-treatment sampling described in Section 2.1.2. One sample was collected from each of the monitoring wells with the exception of MW-62S from which one sample and one duplicate were collected, resulting in a total of 10 groundwater samples.

Samples were collected from all wells for TCL VOC and SVOCs (2-methylnaphthalene only) in laboratory-preserved sample containers. Samples were immediately placed in a cooler with ice following sampling. The water quality parameters were measured during the well purging. All sampling details were recorded on well purge data forms and in the site logbook. The well purge data forms are included in Appendix D.

2.7.2 Long-Term Groundwater Monitoring Results

Groundwater samples collected during the long-term monitoring event were analyzed by Woods Hole Group Laboratories, Raynham, MA for TCL VOCs using USEPA Method 8260B and SVOCs (2-methylnaphthalene only) using USEPA Method 8270C. Table F-1 in Appendix F contains tabulated analytical results for the long-term monitoring groundwater samples collected.

As indicated in Table F-1 in Appendix F, among the nine monitoring wells that were sampled during the long-term monitoring, total VOCs ranged from 51.3 ug/L (MW-42SR) to 2,582 ug/L (MW-63S), total BTEX ranged from 35.2 ug/L (MW-42SR) to 2,047 ug/L (MW-63S), benzene ranged from non-detect (MW-61S) to 91 ug/L (MW-66S), and 2-methylnaphthalene ranged from 0.25 ug/L (MW-61S) to 76 ug/L (MW-64S). Results from the long-term monitoring sampling rounds will be compared with data from other sampling rounds in Section 4.1 to evaluate the effectiveness of the Site 4 thermal treatment remediation and whether the site-specific clean-up goal was achieved.

3.0 WASTE MANAGEMENT

Waste materials were generated during mobilization, remediation activities, and demobilization. The methods used to manage the materials are described in the Work Plan. The following sections describe the quantities of waste materials generated and disposition of these materials. Note that waste streams were the result of the combined Site 3 thermal treatment pilot test and Site 4 thermal treatment remediation. Appendix H contains copies of waste management tracking summary sheets.

3.1 Vapor Collection, Storage, and Disposal

As described in the Work Plan, vapor-phase GAC was used to collect VOCs from the extracted vapor during the thermal treatment. On September 5, 2003, the two primary GAC vessels were removed from service. After removing a GAC vessel from service, the spent carbon within it was removed from the unit and stored on-site in fabric bags for transport off-site. This carbon was sampled on September 5, 2003 and found to be hazardous waste. One spent carbon shipment was made; Appendix H indicates the details regarding this shipment. Four GAC vessels, each capable of holding 1,000 lbs of GAC, and two fabric bags, each holding 1,000 lbs of GAC, were transported off-site as hazardous waste for regeneration at Westates Carbon Arizona's facility in Parker, Arizona on November 12, 2003.

GAC usage was tracked using a PE Photovac MicroFID and by the total days each GAC unit was in service. The GAC usage log is contained in Appendix H.

The GAC system was used during the Site 4 remediation to continuously reduce VOCs in the air effluent stream to the target level of 95% (by weight) (see the Work Plan). Table 3-1 presents the GAC adsorption efficiency as determined by the summa canister vapor sampling events conducted weekly throughout the test. The GAC adsorption efficiency was measured to be greater than 95% in all but one of the seven sampling events. The date during which GAC adsorption efficiency was measured to be low was on August 28, 2003, and this value was 91.8%.

Table 3-1
GAC Adsorption Efficiency

Sampling Date	Site 3 Influent Total VOCs (ppbv)	Site 4 Influent Total VOCs (ppbv)	Site 3 Influent + Site 4 Influent Total VOCs (ppbv)	Combined Effluent Total VOCs (ppbv)	Adsorption Efficiency (%)
07/31/03	18,230	14,752	32,982	28.1	99.91%
08/07/03	10,927	4,808	15,735	21.9	99.86%
08/14/03	108,640	3,793.2	112,433	52.8	99.95%
08/22/03	221,130	8,452	229,582	9,994	95.65%
08/28/03	147,400	79,420	226,820	18,520	91.83%
09/06/03	26,820	12,423	39,243	212.5	99.46%
09/11/03	40,620	116,020	156,640	544.9	99.65%

Note:
Analytical data for Site 4 influent and combined effluent are presented in Tables G-1 and G-2 respectively in Appendix G and summarized in Table 2-2. Analytical data for Site 3 influent are discussed in the Closeout Report for Site 3.

3.2 Soil Collection, Storage, and Disposal

Drill cuttings, consisting of soil only, were generated during the installation of electrodes/VR wells, groundwater monitoring wells, TMPs, and during VR operations (through becoming entrained in groundwater that was extracted). The soil was placed into four plastic-lined 25-yard (23 feet by 8 feet by 75 inches) roll-off containers, three of which were staged in the rear portion of the Site 3 parking lot. One other container was staged on Site 4 near the ERH treatment area. Soils from both the Site 3 ERH Pilot Test and Site 4 ERH treatment were combined in these containers. Waste characterization samples of the soil wastes were collected on August 6, 2003 and October 10, 2003, and most of the soils were found to be of non-hazardous nature. One roll-off was found to contain soils with contaminant concentrations that qualified it for use in asphalt batching. For shipment purposes, soils were stabilized using a polymer material (N^2's Waste Loc 770) and redistributed among eleven 25-yard roll-off containers. Ten of these containers were shipped off-site as non-hazardous waste between October 20-23, 2003 to Waste Management of New Hampshire's disposal facility in Gonic, New Hampshire. The last container was shipped off-site for asphalt batching on October 24, 2003 to Environmental Soil Management's facility in Loudon, New Hampshire. Appendix H provides details regarding these shipments.

3.3 Water Collection, Storage, and Disposal

Water was generated during the installation of electrodes/VR wells, groundwater monitoring wells, and TMPs, well development, groundwater sampling, and VR operation activities. During installation of components, groundwater monitoring well development, and baseline groundwater sampling, approximately 45,000 gallons of water (from both Sites 3 and 4 activities) was generated and stored in 21,000-gallon steel storage tanks. This water was pumped to a groundwater treatment facility located on-site for treatment and subsequent discharge into the Bedford sewage system. Prior to pumping of this water, it was sampled on June 3, 2003 and for VOCs only on July 16, 2003 and found to be acceptable for treatment at this facility. Approximately 71,300 gallons of groundwater and condensate were removed from VR wells during VR operations. Of this amount, approximately 37,500 gallons was recycled as drip water, placed back into the subsurface to maintain saturated conditions in soil adjacent to electrodes. The remainder was utilized as cooling water for the condenser. No excess condensate/groundwater required temporary storage on-site.

Any condensate/groundwater generated during VR operations was treated using liquid-phase GAC prior to its being recycled as drip water or as cooling water. This GAC was sampled on September 5, 2003 and found to be non-hazardous. It was shipped off-site in three United States Department of Transportation (USDOT) Type UN1A2 steel drums as spent non-hazardous GAC for regeneration on November 19, 2003 to US Filter's facility in Avon, Massachusetts. See Appendix H for details regarding this shipment.

3.4 PPE Collection, Storage, and Disposal

PPE used during the thermal treatment remediation was containerized as it was generated into several USDOT Type UN1A2 steel drums along with other general debris that had come into contact with soils or water (plastic, sampling equipment, etc.). The mixed trash was integrated into the soils during their stabilization by the use of polymers and sent off-site for disposal as non-hazardous waste with the soil containers to Waste Management of New Hampshire's disposal facility in Gonic, New Hampshire between October 20-23, 2003 (Appendix H).

4.0 DATA ANALYSIS AND CONCLUSIONS

The following sections present data analysis and conclusions for the Site 4 thermal treatment remediation. Section 4.1 discusses the chemical data collected from the four groundwater sampling rounds as well as the seven vapor sampling events. Section 4.2 assesses whether the objectives of the remediation were met and presents conclusions, and Section 4.3 provides recommendations for the Site 4 thermal treatment remediation project.

4.1 Analysis of Chemical Data for Groundwater and Vapor Samples

Groundwater levels of the monitoring wells were periodically measured by TtEC prior to and after the heating phase. Due to the potential for release of steam, groundwater levels could not be measured during the heating. The groundwater level data are presented in Figure 4-1. As indicated by Figure 4-1, the water levels in the nine monitoring wells inside and outside the treatment area generally followed the same trend. The pre-treatment groundwater levels in these wells measured on May 29, 2003 ranged from 11.25 ft (MW-65S) to 20.30 ft (MW-60S) below top of the carbon steel riser. The water levels measured immediately after the heating on September 29, 2003 indicated that groundwater levels dropped approximately five feet compared to the pre-treatment levels. It is not clear whether this water level drop was due to seasonal groundwater fluctuation, evaporation of the groundwater caused by heating, or a combination of both effects. Groundwater levels measured approximately a year later on August 6, 2004 showed slightly higher water levels than those measured on September 29, 2003 (see Figure 4-1). During the one-year period after the heating was completed, groundwater levels rose and fluctuated following their seasonal patterns.

Groundwater generally flows in a north-westerly direction across the Site 4 treatment area as shown in Figure 4-2. A significant water drop was not observed in the monitoring wells inside the treatment area during the mid-process sampling and immediately following the heating. This suggests that a temporary alteration of the groundwater flow caused by a depression of water table observed at Site 3 during and immediately after the heating did not occur at Site 4. It is assumed that the original north-westerly groundwater flow remained the dominant flow pattern during the heating and after the heating was completed.

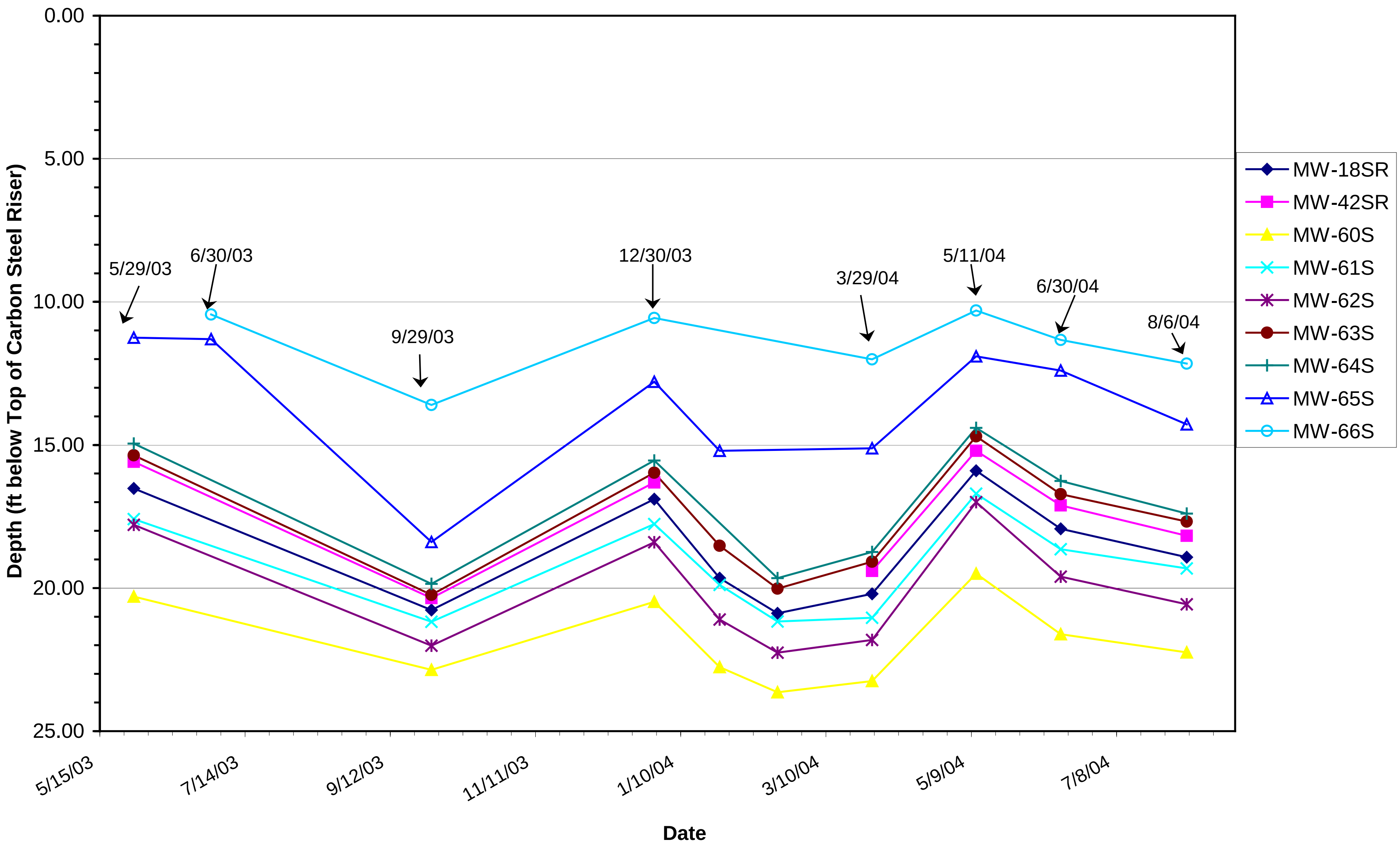
As discussed in Section 2, four groundwater sampling rounds including pre-treatment, mid-process, post-treatment, and long-term monitoring sampling were performed for the three monitoring wells (MW-18SR, MW-63S, and MW-65S) located inside the treatment area. A discussion of the groundwater data for the three wells will be presented in Section 4.1.2. Monitoring wells on the periphery of the treatment area (MW-61S, MW-62S, and MW-64S) and wells adjacent to the treatment area (MW-42SR, MW-60S, and MW-66S) were sampled during the pre-treatment, post-treatment, and long-term monitoring sampling rounds. Data interpretation for these wells will be presented in Section 4.1.3.

For the convenience of data analysis and presentation in this Closeout Report for Site 4, the analytical results of the four COCs (i.e., BTEX), as well as total VOCs and total BTEX, are summarized in Table 4-1 through Table 4-9 for the nine monitoring wells sampled at Site 4. In addition, analytical results for the four COCs for the nine wells are presented graphically in Figure 4-3 through Figure 4-11.

Analytical results for the vapor samples collected during the seven Summa canister sampling events is discussed in Section 4.1.4.

Figure 4-1
Groundwater Levels
Monitoring Wells Located in or Adjacent to Site 4 ERH Zone

Bedford NWIRP



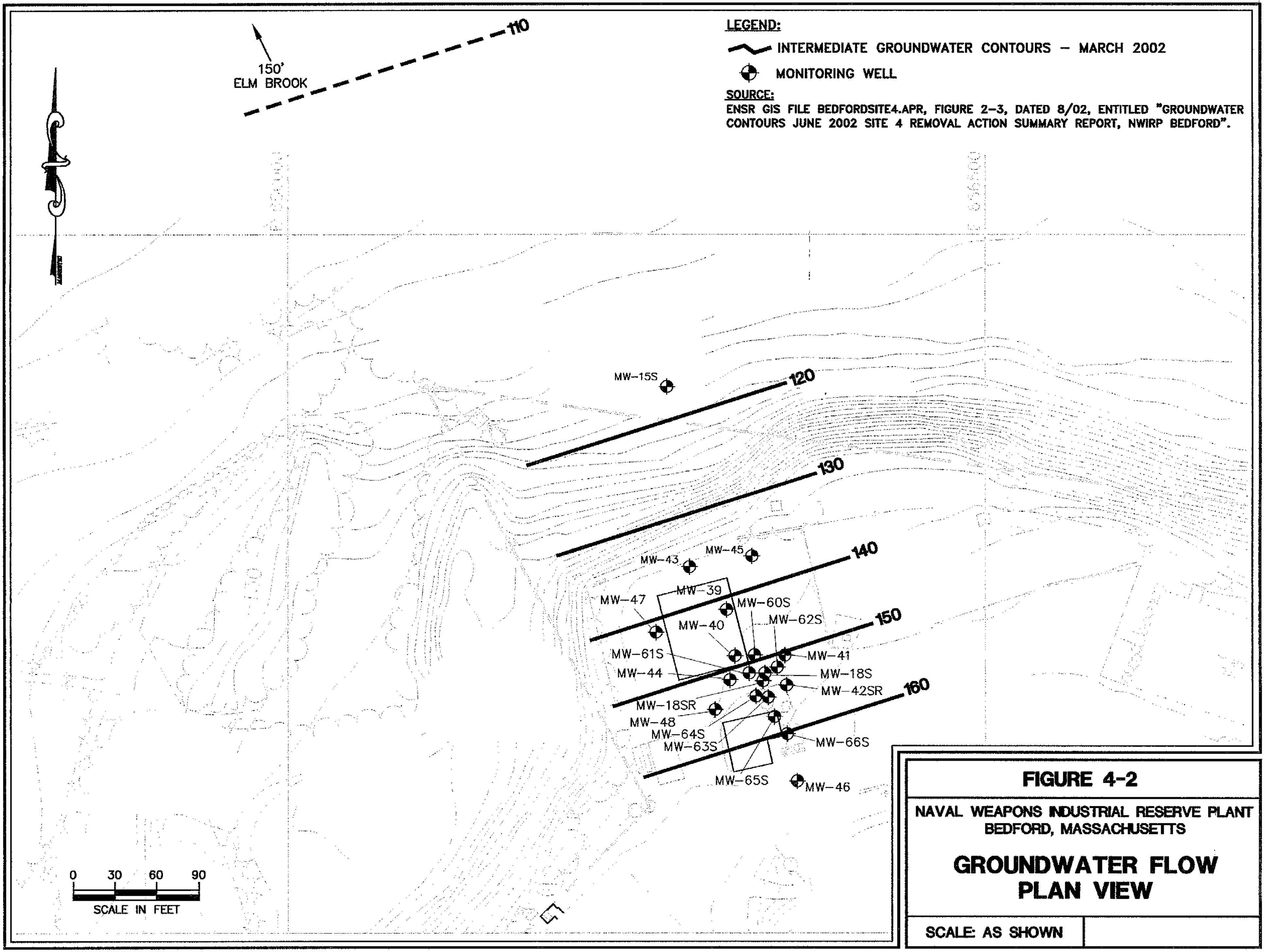


FIGURE 4-2

NAVAL WEAPONS INDUSTRIAL RESERVE PLANT
BEDFORD, MASSACHUSETTS

GROUNDWATER FLOW PLAN VIEW

SCALE: AS SHOWN

CAD FILE: 22820424_A015.DWG

4.1.1 Physical, Chemical and Biological Processes in Groundwater at Site 4

Physical, chemical and biological processes that may have affected the concentrations of contaminants in the Site 4 groundwater are recharge, rebound, increased dissolution/solubility, and biodegradation. These processes are described in the following sections.

4.1.1.1 Recharge

For the purpose of this Closeout Report for Site 4, recharge is defined as groundwater from other areas (e.g. upstream) flowing into the areas of interest. Depending on the concentration of contaminants in the groundwater flowing into the area of interest, an increase, decrease, or no change in concentration of contaminants within the area of interest may be observed.

In the case of Site 4 remediation, an effort was made to extend the treatment area far enough upstream to treat all areas of contaminated groundwater, thereby minimizing potential increases in concentration due to recharge after the thermal treatment.

4.1.1.2 Rebound

For the purpose of this Closeout Report for Site 4, rebound is defined as a contaminant concentration increase in the groundwater inside the treatment area as a result of soil-sorbed contaminants that were not completely removed from the treatment zone re-entering into the groundwater after the thermal treatment. Following the heating, the water-dissolved and soil-bound contaminants would gradually reach an equilibrium during which soil-bound contaminants may partition into the groundwater, causing observed increase in groundwater contaminant concentration in the treatment zone.

4.1.1.3 Increased Dissolution/Solubility

Increased dissolution/solubility is defined as an increase in groundwater contaminant concentration as a result of soil-sorbed contaminants dissolving into the groundwater at an increased rate due to enhanced contaminant solubility in the heated water. This process was thought to occur mostly in areas outside the treatment zone during and immediately after the heating. Groundwater and soil in these areas experienced an increase in temperature and thereby enhanced the dissolution of soil-bound contaminants into the groundwater. However, because these areas were outside or on the periphery of the treatment area, the groundwater temperature in these areas did not rise to a high enough degree for a long enough time to completely volatilize and remove the contaminants. The net result of this solubility enhancement and incomplete removal was the contaminant increase observed in some monitoring wells outside the treatment area during the post-treatment sampling round.

4.1.1.4 Biodegradation

Another process that is thought to be occurring in the groundwater following the heating is biodegradation. Biological breakdown of BTEX and other hydrocarbon compounds by bacteria in groundwater under aerobic (oxygenated) and anaerobic conditions has been widely reported. BTEX can be degraded rapidly by aerobic bacteria, but under anaerobic conditions biodegradation of BTEX is relatively slow (Reinhard et al. 1997).

It is generally believed that natural biological breakdown process ceases during the heating phase due to the extremely high temperature at about 100ºC. After the heating the biological activity begins to increase as the groundwater cools down and would eventually exceed pre-heating biodegradation rates as a result of the warmer groundwater. It is believed that following the completion of the heating at Site 4, biodegradation of BTEX compounds occurred at an increased rate compared to the pre-treatment rate.

4.1.2 Monitoring Wells Inside the Treatment Area (MW-18SR, MW-63S, MW-65S)

The analytical results of the four COCs (BTEX) as well as total VOCs and total BTEX for MW-18SR, MW-63S, and MW-65S are summarized in Tables 4-1, 4-2, and 4-3, respectively. Analytical results for the four COCs for the wells are also plotted in Figures 4-3, 4-4, and 4-5, respectively. The depth of MW-18SR was 28 ft bgs, and the screened interval was 18 ft to 28 ft bgs. MW-63S, with a well depth of 24 ft bgs and a screened interval of 14 ft to 24 ft bgs, was installed on May 16, 2003. MW-65S, with a well depth of 23 ft bgs and a screened interval of 13 ft to 23 ft bgs, was installed on May 17, 2003. Of the three monitoring wells, MW-18SR was on the downstream side of the treatment area; MW-63S was in the center of the treatment area; and MW-65S was on the upstream side of the treatment area (see Figure 1-3).

As indicated by the pre-treatment groundwater results in Tables 4-1, 4-2, and 4-3, as well as Table F-1 in Appendix F, MW-63S demonstrated the highest pre-treatment total BTEX (19,080 ug/L) among the ten monitoring wells sampled during the pre-treatment sampling round. MW-65S also showed high BTEX concentrations at 16,520 ug/L, while MW-18SR had moderate BTEX level at 8,720 ug/L. The pre-treatment groundwater results for MW-63S and MW-65S were consistent with the pre-treatment soil sampling results. Soil samples from these two wells demonstrated the highest total BTEX values (419,000 ug/kg and 346,000 ug/kg respectively) among the seven newly-installed monitoring wells (see Table E-1 in Appendix E). MW-18SR was a replacement well, and no soil sample was collected from the well. In addition, the pre-treatment data for these wells indicated that BTEX compounds composed a major portion of total VOCs, consistent with the site history of contamination from petroleum products.

Significant reduction of groundwater BTEX compounds during the heating (see mid-process data in Tables 4-1 through 4-3) and immediately following the heating (see post-treatment data in Tables 4-1 through 4-3) was observed in the three wells, with reduction rates close to or above 95% for most of the individual COCs and total BTEX. Benzene, the key indicator of remediation performance at Site 4, was at 3.3 ug/L, non-detect, and 6.2 ug/L in MW-18SR, MW-63S, and MW-65S respectively, significantly below the remediation action objective of 50 ug/L.

In addition, unlike the pre-treatment data, the mid-process and post-treatment groundwater results for the three wells showed total BTEX composed only a small portion of total VOCs. A close examination of the mid-process and post-treatment results for individual compounds (see Table F-1 in Appendix F) indicated detections of acetone at higher concentrations than most of the other positively-detected compounds in the mid-process and post-treatment samples. Acetone was probably a by-product of the heating process, and was detected at similar concentration levels in the mid-process and post-test samples collected during the Site 3 pilot test study.

Tables 4-1 through 4-3 showed that compared with the post-treatment groundwater results, total BTEX generally increased in the long-term monitoring samples of the three monitoring wells collected approximately six months after the completion of the heating. With the exception of toluene in MW-18SR and MW-63S, and ethylbenzene in MW-65S, the concentrations of individual COCs all increased to a certain extent in the long-term monitoring samples compared to the results in the post-treatment samples. Nevertheless, benzene, the key indicator of remediation performance at Site 4, was at 41 ug/L, 26 ug/L, and 40 ug/L in MW-18SR, MW-63S, and MW-65S respectively during the long-term monitoring. These benzene concentrations were below the remediation action objective of 50 ug/L.

Table 4-1
MW-18SR Contaminants of Concern

Sample Location	MW-18SR										
Date Collected	6/2/2003		9/9/2003			9/30/2003			4/14/2004		
Sampling Event	Pre-Treatment		Mid-Process			Post-Treatment			Long-Term Monitoring		
Sample Collection Method	peristaltic pump		peristaltic pump			peristaltic pump			peristaltic pump		
Analyte	Conc. (ug/L)	Qual.	Conc. (ug/L)	Qual.	%Reduction from Pre-Treatment	Conc. (ug/L)	Qual.	%Reduction from Pre-Treatment	Conc. (ug/L)	Qual.	%Reduction from Pre-Treatment
Comtaminants of Concern (COCs)											
Benzene	**220**		2.0	U	99.5%	**3.3**	**J**	98.5%	**41**		81.4%
Ethylbenzene	**1200**		**3.1**		99.7%	**15**		98.8%	**650**		45.8%
Toluene	**2200**		**6.8**		99.7%	**24**		98.9%	**13**		99.4%
Xylene	**5100**		**20.7**		99.6%	**104**		98.0%	**850**		83.3%
Total VOCs	**9180**		**226.1**		97.5%	**1040**		88.7%	**1961**		78.6%
Total BTEX	**8720**		**30.6**		99.6%	**146**		98.3%	**1554**		82.2%
2-Methylnaphthalene	**42**		NA			NA			**37**		

Figure 4-3
MW-18SR Contaminants of Concern

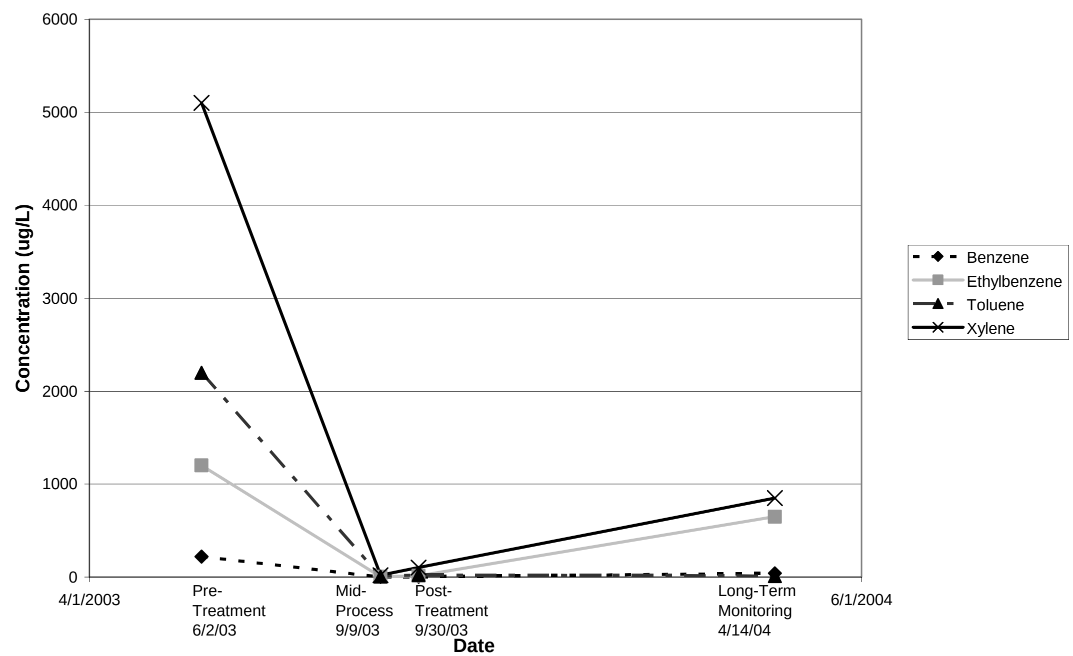


Table 4-2
MW-63S Contaminants of Concern

Sample Location	MW-63S										
Date Collected	6/2/2003		9/9/2003			10/1/2003			4/14/2004		
Sampling Event	Pre-Treatment		Mid-Process			Post-Treatment			Long-Term Monitoring		
Sample Collection Method	peristaltic pump		peristaltic pump			peristaltic pump			peristaltic pump		
Analyte	Conc. (ug/L)	Qual.	Conc. (ug/L)	Qual.	%Reduction from Pre-Treatment	Conc. (ug/L)	Qual.	%Reduction from Pre-Treatment	Conc. (ug/L)	Qual.	%Reduction from Pre-Treatment
Comtaminants of Concern (COCs)											
Benzene	**180**		10	U	97.2%	20	U	94.4%	**26**		85.6%
Ethylbenzene	**1600**		**6.0**	**J**	99.6%	**25**		98.4%	**430**		73.1%
Toluene	**4400**		**14**		99.7%	**27**		99.4%	**27**		99.4%
Xylene	**12900**		**38.0**		99.7%	**86**		99.3%	**1590**		87.7%
Total VOCs	**19785**		**2332.0**		88.2%	**871**		95.6%	**2582**		86.9%
Total BTEX	**19080**		**58.0**		99.7%	**138**		99.3%	**2073**		89.1%
2-Methylnaphthalene	**44**		NA			NA			**60**		

Figure 4-4
MW-63S Contaminants of Concern

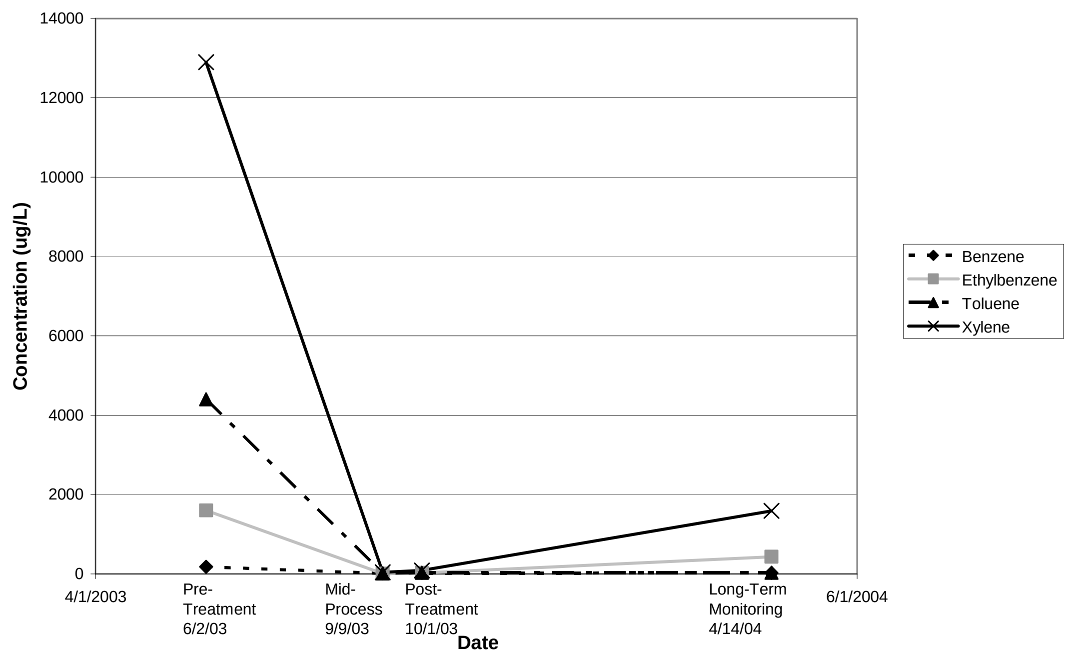
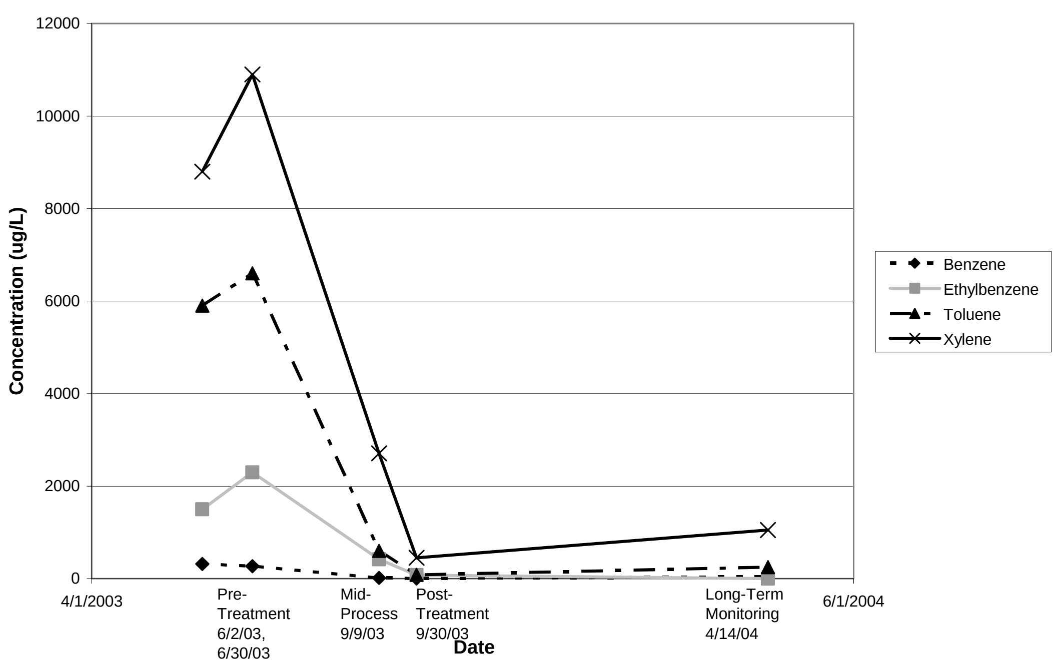


Table 4-3
MW-65S Contaminants of Concern

Sample Location	MW-65S															
Date Collected	6/2/2003		6/30/2003		9/9/2003			9/9/03, Duplicate		9/30/2003			4/14/2004		
Sampling Event	Pre-Treatment (1)		Pre-Treatment (2)		Mid-Process			Mid-Process		Post-Treatment			Long-Term Monitoring		
Sample Collection Method	peristaltic pump		peristaltic pump		peristaltic pump			peristaltic pump		peristaltic pump			peristaltic pump		
Analyte	Conc. (ug/L)	Qual.	Conc. (ug/L)	Qual.	Conc. (ug/L)	Qual.	%Reduction from Pre-Treatment (1)	Conc. (ug/L)	Qual.	Conc. (ug/L)	Qual.	%Reduction from Pre-Treatment (1)	Conc. (ug/L)	Qual.	%Reduction from Pre-Treatment (1)
Comtaminants of Concern (COCs)															
Benzene	**320**		**270**		**18**	**J**	94.4%	**14**	**J**	**6.2**	**J**	98.1%	**40**		87.5%
Ethylbenzene	**1500**		**2300**		**420**		72.0%	**370**		**78**		94.8%	2	U	99.9%
Toluene	**5900**		**6600**		**600**		89.8%	**520**		**81**		98.6%	**250**		95.8%
Xylene	**8800**		**10900**		**2710**		69.2%	**2380**		**450**		94.9%	**1050**		88.1%
Total VOCs	**17080**		**20999**		**5488**		67.9%	**4764**		**1124.1**		93.4%	**1560.2**		90.9%
Total BTEX	**16520**		**20070**		**3748**		77.3%	**3284**		**615.2**		96.3%	**1342**		91.9%
2-Methylnaphthalene	**34**		**80**		NA			NA		NA			**14**		

Figure 4-5
MW-65S Contaminants of Concern



Compared to the post-treatment results, the increases of BTEX concentrations in the long-term monitoring samples may be explained by the combined effects of recharge of groundwater from other areas and rebound from soil-sorbed contaminants. The upstream groundwater that was not treated by ERH may still contain low levels of contaminants that may have been recharged into the wells inside the treatment area. However, the total BTEX concentrations in the long-term monitoring samples of MW-18SR, MW-63S, and MW-65S were at 1,554 ug/L, 2,073 ug/L, and 1,342 ug/L respectively, approximately two to three times of the BTEX concentration (655 ug/L) in MW-66S located upstream and outside the treatment area. This suggests that recharge alone could not account for all the BTEX increase in the long-term monitoring samples collected inside the treatment area.

The other process that may have contributed to the observed BTEX increase during the long-term monitoring was rebound. It is possible that the thermal treatment had not completely removed BTEX from the heavily-contaminated soils, and therefore some amount of soil-bound BTEX compounds may have been left in place inside the treatment area. During the six-month period between the post-treatment and long-term monitoring, the remaining soil-bound contaminants could have partitioned into the groundwater as the system was reestablishing groundwater-soil concentration equilibrium, resulting in the observed BTEX increase in groundwater.

In addition, biodegradation may also have occurred in the groundwater and soil during this period. However, the biodegradation breakdown of BTEX may not be fast enough to offset the concentration increase caused by the other two processes (recharge and rebound) mentioned above.

4.1.3 Monitoring Wells on the Periphery of or Outside the Treatment Area

Monitoring wells outside the treatment area include MW-42SR, MW-60S, MW-61S, MW-62S, MW-64S, and MW-66S that were on the periphery of or outside the treatment area (see Figure 1-3). Monitoring wells with similar contaminant distribution patterns will be grouped together in the following data discussions.

4.1.3.1 MW-61S and MW-64S

The analytical results of the four COCs (BTEX) as well as total VOCs and total BTEX for MW-61S and MW-65S are summarized in Tables 4-4 and 4-5 respectively. Analytical results for the four COCs are also plotted in Figures 4-6 and 4-7 respectively. MW-61S, with a well depth of 25 ft bgs and a screened interval of 15 ft to 25 ft bgs, was installed on May 15, 2003. MW-64S, with a well depth of 24 ft bgs and a screened interval of 14 ft to 24 ft bgs, was installed on May 16, 2003. As can be seen in Figure 1-3, MW-61S was located in the north side (downstream) of the west periphery of the treatment area, and MW-64S was in the center of the west periphery of the treatment area.

As indicated by the pre-treatment groundwater results in Tables 4-4 and 4-5 and Table F-1 in Appendix F, MW-61S and MW-64S demonstrated high pre-treatment total BTEX at 16,776 ug/L and 12,143 ug/L respectively. The pre-treatment soil sampling results also showed that soil samples from MW-61S and MW-64S had relatively high BTEX concentrations at 113,400 ug/kg and 87,700 ug/kg respectively. These values were approximately one-fourth of total BTEX observed in the pre-treatment soil samples collected from MW-63S and MW-65S that were located inside the treatment area (see Table E-1 in Appendix E).

Table 4-4

MW-61S Contaminants of Concern

Sample Location	MW-61S							
Date Collected	5/30/2003		9/30/2003			4/13/2004		
Sampling Event	Pre-Treatment		Post-Treatment			Long-Term Monitoring		
Sample Collection Method	peristaltic pump		peristaltic pump			peristaltic pump		
Analyte	Conc. (ug/L)	Qual.	Conc. (ug/L)	Qual.	%Reduction from Pre-Treatment	Conc. (ug/L)	Qual.	%Reduction from Pre-Treatment
Comtaminants of Concern (COCs)								
Benzene	**76**	**J**	**14**	**J**	81.6%	2	U	98.7%
Ethylbenzene	**290**		**650**		-124.1%	2	U	99.7%
Toluene	**3800**		**830**		78.2%	2	U	100.0%
Xylene	**12600**		**5200**		58.7%	**50**		99.6%
Total VOCs	**17306**		**7281**		57.9%	**63.2**		99.6%
Total BTEX	**16766**		**6694**		60.1%	**56**		99.7%
2-Methylnaphthalene	**42**		NA			0.25	U	

Figure 4-6
MW-61S Contaminants of Concern

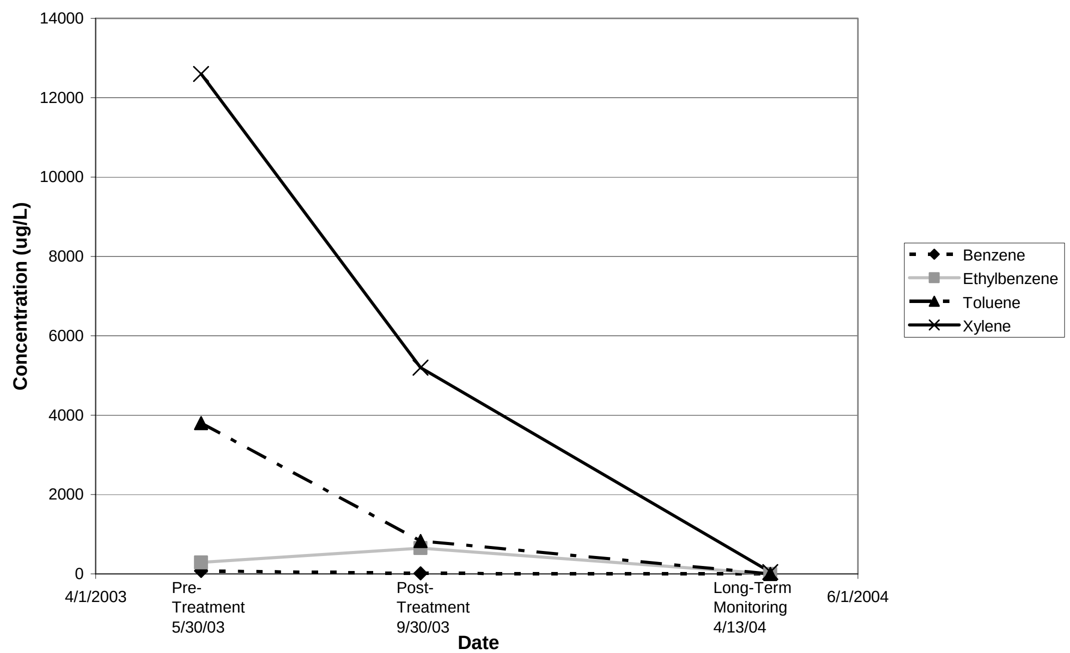
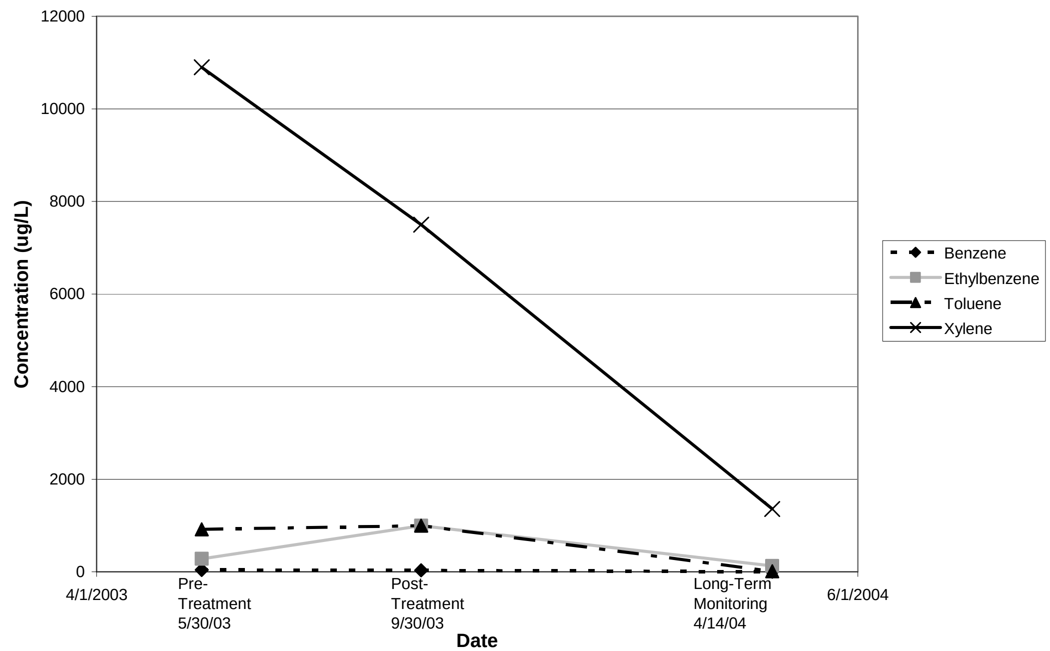


Table 4-5
MW-64S Contaminants of Concern

Sample Location	MW-64S							
Date Collected	5/30/2003		9/30/2003			4/14/2004		
Sampling Event	Pre-Treatment		Post-Treatment			Long-Term Monitoring		
Sample Collection Method	peristaltic pump		peristaltic pump			peristaltic pump		
Analyte	Conc. (ug/L)	Qual.	Conc. (ug/L)	Qual.	%Reduction from Pre-Treatment	Conc. (ug/L)	Qual.	%Reduction from Pre-Treatment
Comtaminants of Concern (COCs)								
Benzene	**43**		**32**	**J**	25.6%	**4.4**		89.8%
Ethylbenzene	**280**		**1000**		-257.1%	**130**		53.6%
Toluene	**920**		**1000**		-8.7%	**13**		98.6%
Xylene	**10900**		**7500**		31.2%	**1360**		87.5%
Total VOCs	**12887**		**14114**		-9.5%	**2002.1**		84.5%
Total BTEX	**12143**		**9532**		21.5%	**1507**		87.6%
2-Methylnaphthalene	**60**		NA			**76**		

Figure 4-7
MW-64S Contaminants of Concern



In the post-treatment groundwater sample for MW-61S, benzene, toluene, and xylene demonstrated reduction rates of 81.6%, 78.2%, and 58.7% respectively compared to their pre-treatment levels, while ethylbenzene increased to 650 ug/L from its pre-treatment level of 290 ug/L. The post-treatment results for MW-64S generally demonstrated the same trend as MW-61S. However, in MW-64S, the reduction rates for benzene and xylene were at 25.6% and 31.2% respectively, lower than those in MW-61S. In addition, in the post-treatment sample for MW-64S, toluene remained at the same level as in the pre-treatment sample, and ethylbenzene increased to 1,000 ug/L from its pre-treatment level of 280 ug/L. Benzene concentrations in the post-treatment samples for MW-61S and MW-64S were at 14 ug/L and 30 ug/L respectively, below the remediation action objective of 50 ug/L.

The reduced reduction of contaminants in groundwater observed in MW-61S and MW-64S during the post-treatment sampling round may be attributed to their locations on the periphery of the treatment area. The groundwater and soil surrounding the two wells may have received some thermal treatment during the heating, but the treatment may not have been enough to remove all the contaminants in the groundwater and soil. Furthermore, immediately after the heating, the hot (but not boiling) water may have led to more soil-bound contaminants to be dissolved into the groundwater, thus increasing the groundwater BTEX concentrations (most notably ethylbenzene) in the post-treatment samples.

The groundwater concentrations of BTEX compounds in the long-term monitoring samples for MW-61S and MW-64S decreased significantly compared with the concentration levels in their pre-treatment and post-treatment samples. Benzene was at a low concentration level of non-detect and 4.4 ug/L in MW-61S and MW-64S respectively during the long-term monitoring, below the remediation action objective of 50 ug/L. Located in the downstream part of the treatment zone, MW-61S and MW-64S may have been receiving groundwater from upstream which was believed to contain low levels of contaminants. The recharge of relatively clean groundwater from upstream may partially be responsible for the significant decrease in contaminant concentrations observed in MW-61S and MW-64S during the long-term monitoring. Biodegradation may have also played a significant role in the reduction of soil and groundwater contaminants in MW-61S and MW-64S during the period between the post-treatment sampling and long-term monitoring.

It is also noted that although MW-61S and MW-64S showed a similar contaminant variation pattern, MW-61S demonstrated a more complete contaminant reduction than MW-64S, especially in the long-term monitoring sampling round. The total BTEX in the long-term monitoring sample for MW-61S was at a low level of 56 ug/L, while the corresponding BTEX concentration in MW-64S was at a moderate level of 1,507 ug/L. The total BTEX value in MW-64S was comparable to concentrations observed in the wells inside the treatment area (MW-18SR, MW-63S, and MW-65S) during the same sampling period.

4.1.3.2 MW-42SR, MW-60S, and MW-62S

The analytical results of the four COCs (BTEX) as well as total VOCs and total BTEX for MW-42SR, MW-60S, and MW-62S are summarized in Tables 4-6, 4-7, and 4-8 respectively. Analytical results for the four COCs for the three wells are also plotted in Figures 4-8, 4-9, and 4-10 respectively. MW-42SR has a well depth of 25 ft bgs and a screened interval of 15 ft to 25 ft bgs. MW-60S, with a well depth of 26 ft bgs and a screened interval of 16 ft to 26 ft bgs, was installed on May 14, 2003. MW-62S, with a well depth of 26 ft bgs and a screened interval of 16 ft to 26 ft bgs, was installed on May 15, 2003. As can be seen in Figure 1-3, MW-42SR was located adjacent to the center of the east periphery of the treatment area; MW-60S was adjacent to the north periphery of the treatment area; and MW-62S was in the corner of the east and north periphery of the treatment area.

Table 4-6
MW-42SR Contaminants of Concern

Sample Location	MW-42SR							
Date Collected	6/2/2003		9/30/2003			4/13/2004		
Sampling Event	Pre-Treatment		Post-Treatment			Long-Term Monitoring		
Sample Collection Method	peristaltic pump		peristaltic pump			peristaltic pump		
Analyte	Conc. (ug/L)	Qual.	Conc. (ug/L)	Qual.	%Reduction from Pre-Treatment	Conc. (ug/L)	Qual.	%Reduction from Pre-Treatment
Comtaminants of Concern (COCs)								
Benzene	**14**		**20**		-42.9%	**2.2**		84.3%
Ethylbenzene	**34**		**65**		-91.2%	**15**		55.9%
Toluene	**1.5**	**J**	**7.4**	**J**	-393.3%	2	U	33.3%
Xylene	**23.2**		**89**		-283.6%	**16**		31.0%
Total VOCs	**122.6**		**259.4**		-111.6%	**51.3**		58.2%
Total BTEX	**72.7**		**181.4**		-149.5%	**35.2**		51.6%
2-Methylnaphthalene	**5.8**		NA			0.27	U	

Figure 4-8
MW-42SR Contaminants of Concern

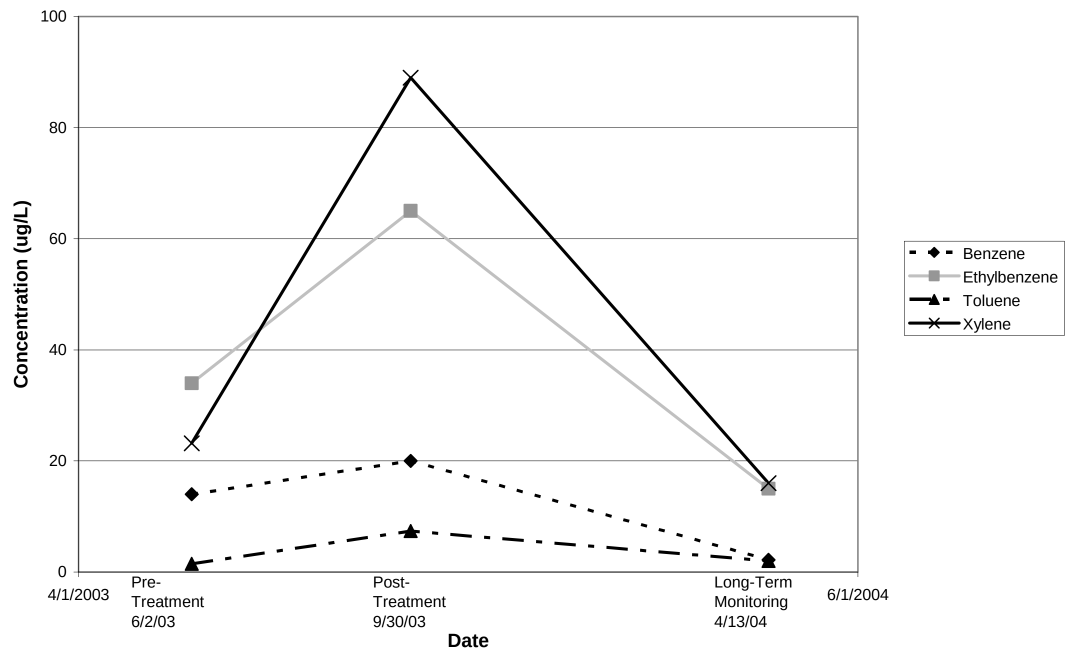


Table 4-7
MW-60S Contaminants of Concern

Sample Location	MW-60S								
Date Collected	5/29/2003		5/29/03, Duplicate		9/29/2003			4/14/2004		
Sampling Event	Pre-Treatment		Pre-Treatment		Post-Treatment			Long-Term Monitoring		
Sample Collection Method	peristaltic pump		peristaltic pump		peristaltic pump			peristaltic pump		
Analyte	Conc. (ug/L)	Qual.	Conc. (ug/L)	Qual.	Conc. (ug/L)	Qual.	%Reduction from Pre-Treatment	Conc. (ug/L)	Qual.	%Reduction from Pre-Treatment
Comtaminants of Concern (COCs)										
Benzene	**250**		**250**		**140**	**J**	44.0%	**7.6**		97.0%
Ethylbenzene	**1600**		**1700**		**2100**		-31.3%	**97**		93.9%
Toluene	**1800**		**2300**		**670**		62.8%	**1.3**	**J**	99.9%
Xylene	**4700**		**5600**		**5700**		-21.3%	**32.5**		99.3%
Total VOCs	**8826**		**10550**		**9309**		-5.5%	**196.3**		97.8%
Total BTEX	**8350**		**9850**		**8610**		-3.1%	**138.4**		98.3%
2-Methylnaphthalene	**30**		**39**		NA			**6.9**		

Figure 4-9
MW-60S Contaminants of Concern

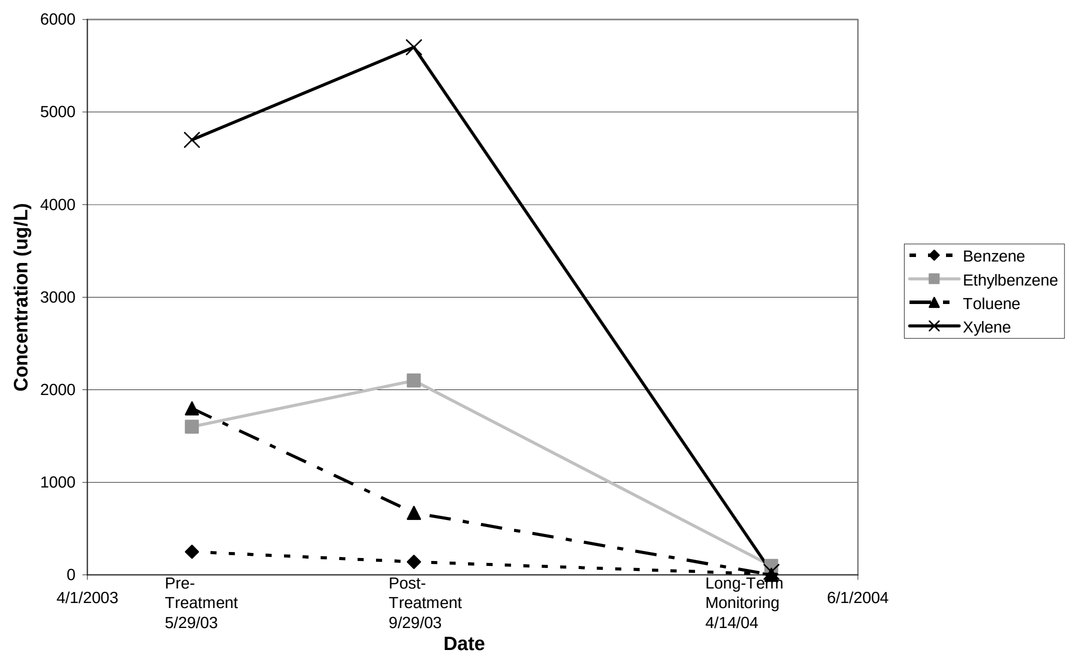
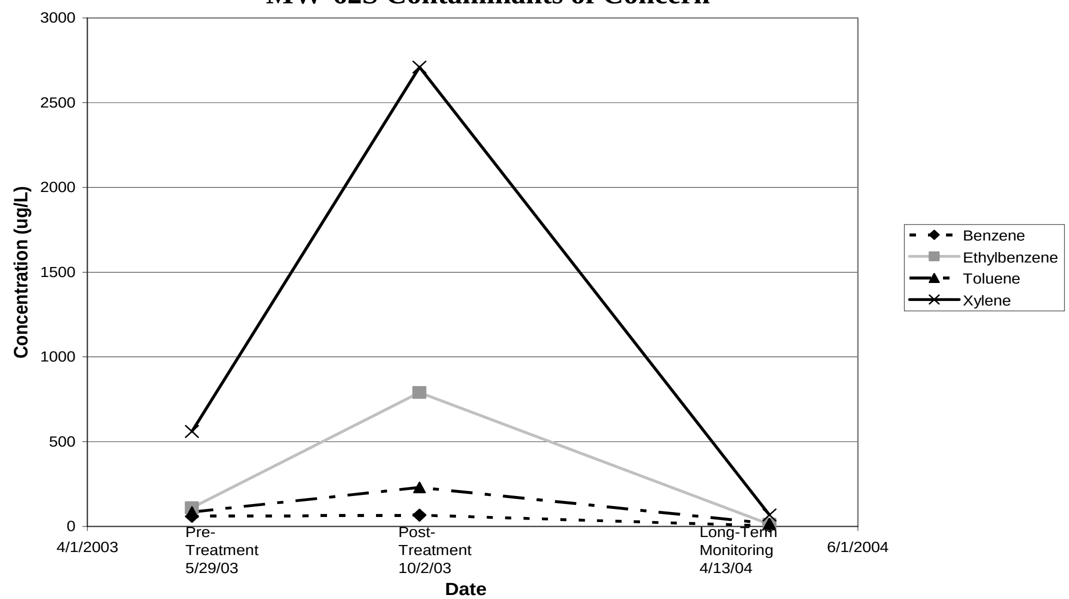


Table 4-8
MW-62S Contaminants of Concern

Sample Location	MW-62S								
Date Collected	5/29/2003		10/2/2003			4/13/2004			4/13/04, Duplicate	
Sampling Event	Pre-Treatment		Post-Treatment			Long-Term Monitoring			Long-Term Monitoring	
Sample Collection Method	peristaltic pump		peristaltic pump			peristaltic pump			peristaltic pump	
Analyte	Conc. (ug/L)	Qual.	Conc. (ug/L)	Qual.	%Reduction from Pre-Treatment	Conc. (ug/L)	Qual.	%Reduction from Pre-Treatment	Conc. (ug/L)	Qual.
Comtaminants of Concern (COCs)										
Benzene	**59**		**66**	**J**	-11.9%	**3.4**		94.2%	**3.5**	
Ethylbenzene	**110**		**790**		-618.2%	**12**		89.1%	**12**	
Toluene	**85**		**230**		-170.6%	**17**		80.0%	**17**	
Xylene	**560**		**2710**		-383.9%	**67**		88.0%	**67**	
Total VOCs	**980**		**4509**		-360.1%	**119.1**		87.8%	**119.7**	
Total BTEX	**814**		**3796**		-366.3%	**99.4**		87.8%	**99.5**	
2-Methylnaphthalene	**29**		NA			**4.6**			**2.2**	

Figure 4-10
MW-62S Contaminants of Concern



As indicated by the pre-treatment groundwater results in Tables 4-6, 4-7, and 4-8, MW-60S demonstrated a moderate pre-treatment total BTEX concentration (8,350 ug/L) comparable to total BTEX in MW-18SR located inside the treatment area. MW-42SR and MW-62S showed low pre-treatment total BTEX concentrations at 72.7 ug/L and 814 ug/L respectively. The pre-treatment soil sampling results indicated that total BTEX in the soil sample from MW-60S was at a relative high level of 139,600 ug/kg, while the soil sample from MW-62S had total BTEX at a low level of 900 ug/kg. No soil sample was collected from replacement well MW-42SR.

In the post-treatment groundwater sample for MW-60S, benzene and toluene demonstrated reduction rates of 44.0% and 62.8% respectively compared to their pre-treatment levels, while ethylbenzene and xylene increased slightly relative to the pre-treatment results. MW-42SR and MW-62S showed similar increase in concentrations of all the four COCs in post-treatment samples compared with their pre-treatment levels. Benzene concentration in the post-treatment sample for MW-42S was at 20 ug/L, below the remediation action objective of 50 ug/L. However, post-treatment benzene concentrations for MW-60S and MW-62S were at 140 ug/L and 66 ug/L respectively, exceeding the remediation action objective.

The general increase in contaminant concentrations observed in the post-treatment samples for MW-42SR, MW-60S, and MW-62S may be attributed to the dissolution of originally soil-bound contaminants into the post-treatment groundwater. Due to their locations on the periphery of or outside the treatment area, these three wells may have received some heating during the thermal treatment, but the heating was not enough to completely remove the contaminants in the groundwater and soil. During and immediately after the heating, the warmer temperature in the surrounding groundwater and soil may have resulted in more soil-bound contaminants being dissolved into the groundwater. The net result of the incomplete contaminant removal and solubility enhancement may have led to the observed concentration increase in the post-treatment samples.

The concentrations of BTEX compounds in the long-term monitoring samples for MW-42SR, MW-60S, MW-62S decreased significantly compared with the concentration levels in their pre-treatment and post-treatment samples. Among the three wells, MW-60S demonstrated the most significant contaminant decrease with a reduction rate of 98.3% for total BTEX. More importantly, benzene concentrations in the long-term monitoring samples for MW-42SR, MW-60S and MW-62S were at low concentration levels of 2.2 ug/L, 7.6 ug/L, and 3.5 ug/L respectively. These values demonstrated a significant decrease from the elevated post-treatment results, and were below the remediation action objective of 50 ug/L.

Due to their location in the downstream part of the treatment area, recharge of relatively clean groundwater from south-east direction (upstream) may have contributed to the decrease in contaminant concentrations observed in MW-42SR, MW-60S, and MW-62S during the long-term monitoring. In addition, the contribution of biodegradation in the reduction of soil and groundwater contamination could not be ruled out. Among the three wells, the effect of biodegradation may have been most significant in MW-60S where a moderate pre-treatment BTEX concentration and a subsequent post-treatment increase were observed.

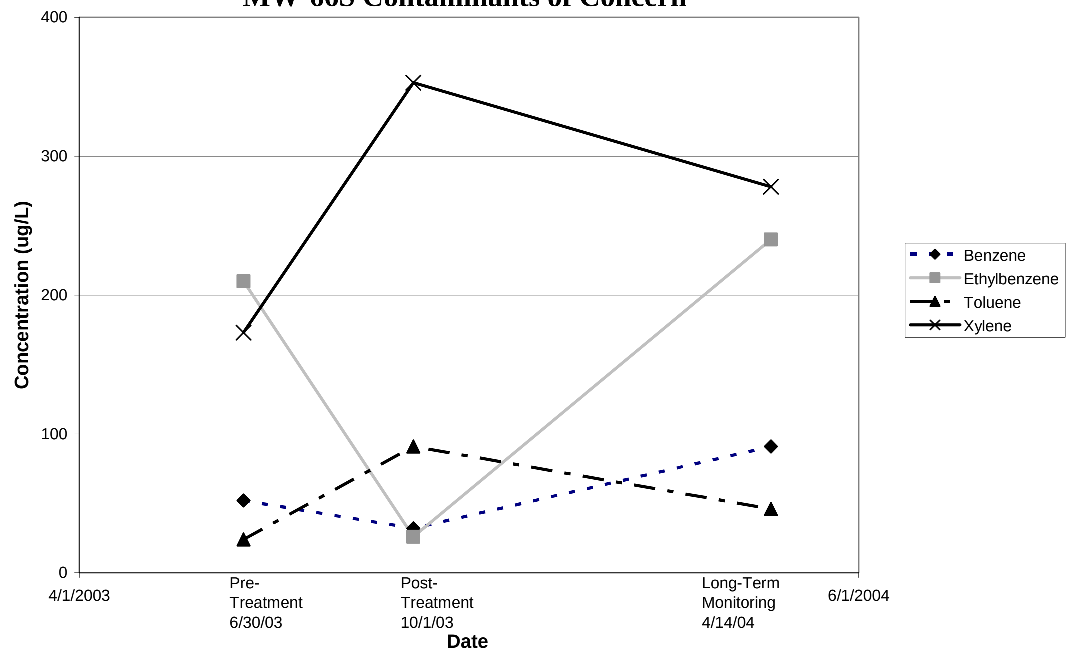
4.1.3.3 MW-66S

The analytical results of the four COCs (BTEX) as well as total VOCs and total BTEX for MW-66S are summarized in Table 4-9. Analytical results for the four COCs for the well is also plotted in Figure 4-11. MW-66S, with a well depth of 19 ft bgs and a screened interval of 9 ft to 19 ft bgs, was installed on June 26, 2003. As can be seen in Figure 1-3, MW-66S was located outside the south periphery of the treatment area.

Table 4-9
MW-66S Contaminants of Concern

Sample Location	MW-66S									
Date Collected	6/30/2003		10/1/2003			10/1/03, Duplicate		4/14/2004		
Sampling Event	Pre-Treatment		Post-Treatment			Post-Treatment		Long-Term Monitoring		
Sample Collection Method	peristaltic pump		peristaltic pump			peristaltic pump		peristaltic pump		
Analyte	Conc. (ug/L)	Qual.	Conc. (ug/L)	Qual.	%Reduction from Pre-Treatment	Conc. (ug/L)	Qual.	Conc. (ug/L)	Qual.	%Reduction from Pre-Treatment
Comtaminants of Concern (COCs)										
Benzene	**52**		**32**		38.5%	**32**		**91**		-75.0%
Ethylbenzene	**210**		**26**		87.6%	**26**		**240**		-14.3%
Toluene	**24**		**91**		-279.2%	**86**		**46**		-91.7%
Xylene	**173**		**353**		-104.0%	**340**		**278**		-60.7%
Total VOCs	**522.3**		**559.7**		-7.2%	**538.4**		**719.5**		-37.8%
Total BTEX	**459**		**502**		-9.4%	**484**		**655**		-42.7%
2-Methylnaphthalene	**1.1**		NA			NA		**1.6**		

Figure 4-11
MW-66S Contaminants of Concern



As indicated by the pre-treatment groundwater results in Table 4-9 and Table F-1 in Appendix F, MW-66S demonstrated a low pre-treatment total BTEX at 459 ug/L. The pre-treatment soil sampling results (see Table E-1 in Appendix E) indicated that the soil sample from MW-66S only had ethylbenzene positively detected at 40 ug/kg, and total BTEX for the sample was the lowest among the soil samples collected from the seven newly-installed monitoring wells.

In the post-treatment sample for MW-66S, benzene and ethylbenzene demonstrated an increase while toluene and xylene showed a decrease compared to their pre-treatment levels. Post-treatment benzene concentration for MW-66S was at 32 ug/L, below the remediation action objective of 50 ug/L. Located in the upstream and outside of the treatment area, MW-66S was believed to have received minimum thermal treatment during the heating. However, some mixing of warm water from the treatment zone may still have occurred in this monitoring well during and immediately after the heating, which may explain the variations in BTEX concentrations observed in the post-treatment data.

The long-term monitoring results for MW-66S indicated that the contaminant composition (relative ratios among BTEX compounds) in the groundwater returned to the pre-treatment values, and a general increase in BTEX concentrations was observed. Benzene concentration in the long-term monitoring sample for MW-66S was at 91 ug/L, above the remediation action objective of 50 ug/L. The similarity of contaminant composition between the pre-treatment and long-term monitoring data for MW-66S indicated that recharge of the groundwater from further upstream was the dominant process that affected its long-term monitoring results.

It is also worth pointing out that due to the low level of contamination in MW-66S, the variation in contaminant concentrations observed in this well during the different sampling rounds were within the range of sampling and analytical errors.

4.1.4 Analysis of Vapor Data

As discussed in Section 2.3.4 and its sub-sections, seven vapor sampling events occurred on a weekly basis to monitor the VOC concentrations in the influents and effluent of the VR system. In addition, FID, PID LEL, vacuum, and vapor flow data were also collected nearly daily during the VR system operation. The analytical results for the Site 4 vapor influent and combined effluent are summarized in Tables G-1 and G-2 in Appendix G, and the system monitoring data are included in Table 2-2.

As indicated in Table 2-2, Site 4 influent FID, LEL and Summa canister readings on the VR system initialization day (July 31, 2003) were 9,800 ppmv, 20%, and 14.8 ppmv respectively. The corresponding combined effluent readings for these parameters were 5,240 ppmv, 21%, and 0.028 ppmv respectively. Although the Summa canister vapor data showed a significant reduction of total VOCs by the VR system, the effluent LEL reading was higher than the influent reading, indicating no removal of certain constituents by the VR system. This observation promoted additional collection of grab vapor samples (using Summa canisters) for the analysis of methane to determine the possible cause of the poor removal of constituents with high FID and LEL readings.

Methane results in Tables G-1 and G-2 in Appendix G indicated that on July 31, 2003, the methane concentration was 0.22% at the Site 4 influent and 0.31% at the effluent. The high methane concentration and low reduction rate of LEL constituents in the combined effluent vapor stream suggested that methane may be a significant constituent responsible for the high FID and LEL readings on the system initialization day. The significant presence of methane in the vapor stream was unexpected, and the sources of the methane have not been determined. In the subsequent two weeks of vapor sampling events, methane concentrations decreased to 0.025% and 0.045% respectively at Site 4 influent and

0.027% and 0.036% respectively at the combined effluent. Methane analysis was discontinued after the third week of vapor sampling due to the dissipating levels. The use of a PID in addition to a FID was incorporated into the sampling procedures in an attempt to differentiate the methane levels.

The individual VOC results shown in Table G-1 in Appendix G indicated that the chemical composition of the Site 4 vapor stream generally matched well with the compounds detected in the Site 4 groundwater samples, with the BTEX compounds as the dominant contaminants.

The Site 4 influent vapor Summa canister data, along with the Site 4 influent flow rate, vacuum, and temperature data, was used to calculate daily VOC mass removal amounts for Site 4 (see Table 2-2). Daily VOC removal rates ranged from 0.1 to 5.7 lbs VOC per day. It is estimated that approximately 69.5 lbs of VOCs were removed during the period of the ERH system operation.

The ERH operation was performed for 53 days, from July 31 to September 22, 2003. Based on the information that the mid-process groundwater samples collected from both Site 3 and Site 4 met the clean-up goals, a decision was made to permanently leave off the electrodes on September 22, 2003. To fully collect the vapor contaminants that were still coming out of the groundwater after the ERH system was turned off, VR system remained in operation for an extended period of time until October 9, 2003.

During the 53-day ERH operation period, changes in the VOC concentrations of the Site 3 and Site 4 influent vapor reflected the variation in contaminant removal rates by the ERH system. The influent VOC concentration was expected to increase from a low point near the beginning, reach a maximum near the middle of the operation, and then decrease to a low point indicating completion. The low influent VOC concentration near the end of the operation would indicate that the majority of the contaminants in the groundwater and soil had been removed. VOC concentrations in the Site 3 influent generally followed this trend, with the highest concentration observed in the middle of the ERH operation on August 22, 2003. However, at Site 4, the highest vapor VOC concentration was observed in the last Summa canister sampling round on September 11, 2003, suggesting that the maximum contaminant removal rate was reached close to the end of the ERH operation. Since additional Summa canister samples were not collected near the end of the treatment, it was not clear whether VOC concentration in the Site 4 influent had decreased to a low level at the time of the ERH system shut-off. It is possible that the Site 4 influent vapor still contained a relatively high level of contaminants at the time heating was terminated, indicting that some contamination may have been left untreated in the treatment zone.

4.2 Conclusions

The objectives for Site 4 thermal treatment remediation were to significantly reduce the overall mass of petroleum-derived VOCs in the source area and to achieve benzene concentration of 50 ug/L in the Site 4 groundwater. The analytical results from the various groundwater sampling events, primarily the long-term monitoring data in comparison with the pre-treatment data, were used to evaluate whether these objectives have been achieved. The evaluation of the objectives focused on the monitoring wells inside and on the periphery of the treatment area including MW-18SR, MW-61S, MW-62S, MW-63S, MW-64S, and MW-65S. The project objectives were also compared with results from monitoring wells outside the treatment area including MW-42SR, MW-60S and MW-66S, where complete removal of the BTEX contaminants was not expected.

The long-term monitoring results indicated that compared to the pre-treatment data, the overall mass of petroleum-derived VOCs in the source area has been significantly reduced. The reduction rates of total BTEX observed during the long-term monitoring for MW-18SR, MW-61S, MW-62S, MW-63S, MW-64S, and MW-65S were 82.2%, 99.7%, 87.8%, 89.1%, 87.6%, and 91.9% respectively. The concentrations of benzene, the key indicator of remediation performance at Site 4, were at 41 ug/L, non-detect, 3.4 ug/L, 26 ug/L, 4.4 ug/L, and 40 ug/L respectively, all below the site remediation action objective of 50 ug/L. All these long-term monitoring results indicated that the remediation objective for Site 4 has been achieved.

MW-42SR and MW-60S, the two downstream monitoring wells outside the treatment area, had benzene concentrations below the remediation objective at 2.2 ug/L and 7.6 ug/L respectively in their long-term monitoring samples. The only exceedance to the remediation objective in the long-term monitoring data set was a benzene concentration at 91 ug/L detected in MW-66S. Because MW-66S is located upstream and outside of the treatment area, a significant reduction of the contaminants from the area was not expected.

Inside the treatment area, groundwater BTEX contamination had been reduced to low levels during and immediately after the heating, as indicated by the mid-process and post-treatment sampling results. However, the long-term monitoring data collected six months after the heating demonstrated a moderate increase in BTEX concentrations compared to the post-treatment results. Recharge of groundwater from upstream of the treatment area could not account for all the contaminant increase, because the BTEX concentration in the upstream groundwater was only one-third of the concentrations observed in the groundwater inside the treatment area. It is hypothesized that a fraction of the observed contaminant increase may be due to rebound of the soil-sorbed contaminants that were not completely removed by the thermal treatment. During the period between the pre-treatment sampling and long-term monitoring, these soil-bound contaminants may have partitioned into the groundwater, contributing to the observed BTEX increase. The hypothesized rebound effect was further supported by the fact that the VOC concentration in the Site 4 influent vapor reached its maximum close to the end of the operation. This suggested that some amount of contaminants may have been left untreated inside the treatment area at the time heating was terminated and subsequently contributed to the BTEX increase in groundwater. In addition, biodegradation is believed to be occurring inside the treatment area at an increased rate compared to the corresponding biodegradation rate prior to the thermal treatment. Accelerated biodegradation was also observed at Site 3 after the thermal treatment. However, biological breakdown process may not be fast enough inside the treatment area at Site 4 to offset any effects of recharge and rebound.

On the periphery of and outside the treatment area, a temporary BTEX concentration increase was observed immediately after the heating due to increased solubility of the contaminants in the groundwater. The contaminants in these areas were significantly reduced to low concentration levels during the long-term monitoring, probably as a result of accelerated biodegradation, or a combined result of recharge of clean groundwater from other areas and biodegradation.

4.3 Recommendations

It is recommended that additional groundwater monitoring be conducted in the future to monitor the contamination levels to see if they continue to remain below site remediation goal of 50 ug/L benzene in the groundwater. The availability of the future monitoring data may help elucidate the roles the chemical, physical, and biological processes are playing in the transport and fate of the BTEX contaminants, and predict the trend of natural attenuation throughout the site.

Furthermore, it is recommended that an additional round of soil sampling be conducted at the site. The soil samples should be collected from the same locations and depths where the pre-treatment soil samples were taken. As discussed in Section 4.1.2, rebound of soil-sorbed contaminants that were not completely removed by the thermal treatment may be one of the processes that were responsible for the moderate BTEX increase in the long-term monitoring samples collected inside the treatment area. The soil data from the recommended additional sampling, in combination with the pre-treatment soil data, will help clarify whether rebound process is occurring and its contribution to the overall contaminant distribution.

5.0 REFERENCES

Foster Wheeler Environmental Corporation. July 2003. *Thermal Treatment Pilot Test and Remediation QA/QC Plan, Naval Weapons Industrial Reserved Plant, Bedford, Massachusetts, Rev. 2.*

Foster Wheeler Environmental Corporation. August 2003. *Final Site -Specific Health and Safety Plan for Site 3 and Site 4 Thermal Treatment, Naval Weapons Industrial Reserved Plant, Bedford, Massachusetts, Rev. 0.*

Foster Wheeler Environmental Corporation. December 2003. *Final Work Plan for Site 4 Thermal Treatment, Naval Weapons Industrial Reserved Plant, Bedford, Massachusetts, Rev. 0.*

Reinhard, M., S. Shang, P. K. Kitanidis, E. Orwin, G. D. Hopkins, and C. A. Lebron, 1997. *In Situ BTEX Biotransformation Under Enhanced Nitrate- and Sulfate-Reducing Conditions.* Environmental Science and Technology, 31: 28-36.

Tetra Tech EC, Inc. April 2005. *Draft Closeout Report for Site 3 Thermal Treatment Pilot Test, Naval Weapons Industrial Reserve Plant, Bedford, Massachusetts, Rev. 0.*

TRS. April 2003. *System Design and Work Plan, Electrical Resistance Heating Remediation Site 4, Naval Weapons Industrial Reserve Plant, Bedford, Massachusetts*.

APPENDIX A

Thermal Remediation Services, Inc.
Site 4 Thermal Treatment Final Report

FINAL REPORT

Electrical Resistance Heating Operations

Site 4 Extended Thermal Treatment Area

Bedford Naval Weapons Industrial Reserve Plant (NWIRP)

Bedford, MA.

U.S. NAVY REMEDIAL ACTION CONTRACT

N62472-99-R-0032

Prepared by

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LIST OF ACRONYMS AND ABBREVIATIONS

Term	Definition
^{o}C	Degrees Celsius
1,1,1-TCA	1,1,1-Trichloroethane
1,1-DCA	1,1-Dichloroethane
cis 1,2-DCE	1,2-Dichloroethene
acfm	Actual Cubic Feet Per Minute
bgs	Below Ground Surface
BTEX	Benzene, toluene, ethylbenzene, xylene
cm/s	Centimeters Per Second
CPVC	Chlorinated Polyvinyl Chloride
CVOCs	Chlorinated Volatile Organic Compounds
DNAPLs	Dense Non-Aqueous Phase Liquids
ERH	Electrical Resistance Heating
ft^3	Cubic Feet
GAC	Granular Activated Carbon
gpm	Gallons per minute
kW-hr	Kilowatt Hour
MCM	One thousand circular mils
MW	Monitoring Well
NWIRP	Naval Weapons Industrial Reserve Plant
μg/l	Microgram Per Liter
PCE	Tetrachloroethene
PCU	Power Control Unit
ppmv	Parts Per Million By Volume
PVC	Polyvinyl Chloride
scfm	Standard Cubic Feet Per Minute
TCE	Trichloroethene
TRS	Thermal Remediation Services, Inc.
TTFW	Tetra-Tech Foster Wheeler
TTNUS	Tetra-Tech NUS
TMPs	Temperature Monitoring Points
USEPA	United States Environmental Protection Agency
VOCs	Volatile Organic Compounds
VR	Vapor Recovery
yd^3	Cubic Yard

EXECUTIVE SUMMARY

An Electrical Resistance Heating (ERH) extended treatment area application was conducted at Site 4 of the Bedford Naval Weapons Industrial Reserve Plant (NWIRP), Bedford, Massachusetts by Thermal Remediation Services, Inc. (TRS) under subcontract to Tetra Tech Foster Wheeler Environmental Corporation (TTFW) for the U.S. Navy Engineering Field Activity Northeast Remedial Action Contract (RAC) N62472-99-R-0032, Task Order 0089. The extended treatment area was conducted to remediate benzene in groundwater to 50 parts per billion (ppb).

Concentrations of benzene, toluene, ethylbenzene and xylene (BTEX) were detected in groundwater samples collected after an underground storage tank (UST) removal was completed in 1990. The UST previously contained gasoline and post removal groundwater sampling activities reported BTEX concentrations in an existing monitoring well, MW-18, ranging from 50 to 60 parts per million (ppm). Previous remediation activities included three rounds of chemical oxidation treatment from 2000 to 2002; however, post chemical oxidation treatment groundwater results reported that BTEX concentrations still exceeded 20 ppm (TTFW Statement of Work 2002).

The ERH treatment application was conducted as an extension of an ERH Pilot Test at Site 3 which was being evaluated for potential full-scale application for removal of chlorinated volatile organic compounds (CVOCs) at a previously-delineated source area near the Chemical Storage Building and Components Laboratory (Site 3). The Site 4 extended treatment was operated concurrently with the Site 3 Pilot Test via the same Power Control Unit (PCU). As indicated in the TTFW Statement of Work, the goal of the Site 4 extended ERH treatment was to reduce existing benzene concentrations in groundwater to the 50 ppb cleanup level.

A treatment volume 20 feet wide, 50 feet long, and 28 feet deep was delineated east from the southeast corner of the Antenna Range Building, which is approximately 3,150 feet northwest from the Site 3 ERH Pilot Test. The proposed treatment area at Site 4 was expanded from the original dimensions of 20 feet wide by 30 feet long after increased BTEX concentrations were detected upgradient from the site. The extended treatment area subsurface ERH treatment interval was from approximately 9.5 feet to 28 feet below grade surface (bgs), resulting in a potential treatment volume of 719 cubic yards (yd^3). A total of eight electrodes with co-located vapor recovery wells were installed to a depth of 30 feet bgs (i.e., two feet beyond the proposed treatment interval of 28 bgs). The electrode design allowed subsurface power application and vapor recovery to be performed simultaneously within each boring. Subsurface temperatures were measured at three temperature monitoring points (TMPs) located within the treatment area.

Recovered groundwater, soil vapors, and steam from Site 4 were separated in the condenser unit of the ERH process treatment system. The vapor stream was processed through four, 1000-pound (lb) granular activated carbon (GAC) vessels for contaminant removal. Condensate and recovered groundwater was treated using a single 55-gallon liquid GAC vessel and was either returned to the subsurface via drip lines installed in each electrode boring or was evaporated via the on-site condenser cooling tower. Approximately 167,070 kilowatts hours (kW-hr) of energy was applied to the subsurface during the 53 days of operation (operational period for Site 3 ERH Pilot Test). The average temperature within the treatment volume, based on the average temperatures recorded at the three TMP locations, reached a high of 93 degrees Celsius (^{o}C) on day 51 of operations. The average subsurface treatment interval temperatures at the three TMP locations were 93 ^{o}C, 100 ^{o}C, and 84 ^{o}C at TMP-1, -2 and -3, respectively.

The Site 4 ERH operations were shutdown when the directive from TTFW was given to officially shutdown the Site 3 ERH Pilot Test on September 22, 2003. The analysis of groundwater samples collected from Site 4 September 2003 after the cessation of ERH operations indicated that benzene concentration was below the 50 ppb remediation goal at all monitoring well locations within the treatment area. Subsequent sampling events in October 2003 and April 2004 reported that benzene concentrations remained below the cleanup goal; however, there was a laboratory qualifier (J for estimated value) added to the October 2, 2003 sample collected from MW-62S. The April 2004 sample results, including a duplicate sample, confirmed that the benzene concentration at that location (3.4 micrograms per liter (μg/L) or ppb) remained below 50 μg/L cleanup goal.

Monitoring well location MW-66S indicated a rise in benzene concentrations from 14J μg/L in September 2003 to 91 μg/L based on the analytical results of the April 2004 groundwater sampling event. Based on the location of MW-66S south of the Site 4 treatment area, the monitoring well is likely upgradient of the site with regards to general groundwater flow direction, and its increase in benzene concentration indicates the potential for recontamination of the treatment area.

1.0 INTRODUCTION

1.1 PURPOSE OF THE REPORT

This report presents the results of the Electrical Resistance Heating (ERH) remediation application at Site 4 of the Bedford Naval Weapons Industrial Reserve Plant (NWIRP), Bedford, Massachusetts. The operations were officially titled Extended Treatment Area in reference to the fact that Site 4 was operated concurrently via the same Power Control Unit (PCU) as the Site 3 ERH Pilot Test. The ERH application at Site 4 was conducted to remediate known and suspected concentrations of benzene in the groundwater attributable to a former underground storage tank (UST) to a cleanup level of 50 micrograms per liter (μg/L).

Thermal Remediation Services (TRS) has prepared this report under subcontract to Tetra Tech Foster Wheeler Environmental Corporation (TTFW) for the U.S. Navy Engineering Field Activity Northeast (EFA NE) Remedial Action Contract (RAC) N62472-99-R-0032, Task Order 0089. The information presented in this report is based on ERH operations results and data collected from various media during and after ERH operations at the site. This report presents the data from Site 4 operations as well as associated conclusions and recommendations.

1.2 BACKGROUND INFORMATION

1.2.1 Site Location, Geology and Description

The Bedford NWIRP is located approximately 15 miles northwest of Boston, in Bedford, Massachusetts (refer to Figure 1: Bedford NWIRP Location Map and Aerial Photo). The former NWIRP is comprised of approximately 46-acres of densely developed land with a geographical high to the north (Hartwells Hill) with some wetlands located north and west of Hartwells Hill and to the east and northeast as well.

The ERH system was constructed and operated at Site 4, a subsurface source area with a dissolved phase constituent plume east from the southeast corner of the Antenna Range Building on the northern slope of Hartwells Hill (refer to Figure 2: Site 4 Location Map). The Site 4 location is approximately 3,150 feet northwest and down the slope of Hartwells Hill from the Site 3 ERH Pilot Test. The ERH treatment area, as shown on Figure 3: Site 4 Extended Treatment Area, comprised an area 20 feet wide by 50 feet long, with a remediation design interval of approximately 9.5 to 28 feet below ground surface (bgs).

The Bedford NWIRP was primarily constructed on Hartwells Hill, within the drainage basin of the Shawsheen River (refer to Figure 1). The hill, a diorite knob capped by glacial till, rises approximately 70 feet above the surrounding wetlands (http://5yrplan.nfesc.navy.mil/1997). The glacial deposits are comprised of sandy till, silty till and dense, clayey till. The upper 10 feet of the pilot study area is considered fill (i.e., re-worked till of sand and gravel) from the construction of the NWIRP and its various buildings and structures (TTFW 2002). Groundwater is primarily influenced by topography: precipitation at the site generally migrates radially off the hill with slow to minor penetration of the poorly drained soil due to the lack of remaining natural surface cover (http://5yrplan.nfesc.navy.mil/1997). Previous investigation results and groundwater contours based on shallow and intermediate zones support a primary groundwater flow in a north/northwesterly direction from Hartwell Hill. Permeability tests (i.e., slug tests) and geotechnical laboratory tests indicate a low hydraulic conductivity in the pilot test area ranging from an average of 3.5×10^{-5} centimeters per second (cm/s) to 11.20×10^{-7} cm/s (TTFW 2002).

1.2.2 Historic and Current Land Use

Former Bedford NWIRP activities included the design, fabrication and testing of prototype weapons and missile guidance systems. The facility was operated by Raytheon Company of Waltham, Massachusetts until operations ceased in December 2002. Raytheon Company removed the UST in the vicinity of Site 4 in 1990. The NWIRP facility is currently vacant (TTFW 2002).

1.3 PREVIOUS INVESTIGATIONS AND REMEDIATION EFFORTS

According to information provided in the 2002 TTFW Statement of Work, previous investigations conducted at Site 4 after the UST was removed indicated benzene, toluene, ethylbenzene and xylene (BTEX) concentrations in groundwater in excess of 50 milligrams per liter (mg/L) at monitoring well location MW-18. Additional groundwater samples also indicated that benzene concentrations were near 600 μg/L. Consequently, three separate chemical oxidation remediation efforts were conducted by GeoCleanse for the US Navy from 2000 to 2002. Post chemical oxidation treatment groundwater results from MW-18 indicated that BTEX concentrations at MW-18 still exceeded 20 mg/L (TTFW, 2002).

1.4 REPORT ORGANIZATION

In order to reduce the length and redundancy of this ERH Extended Treatment Area Report for Site 4, the reader will be referred to previous materials when appropriate to minimize reiteration of information that has not changed from previous documents (e.g., site history, regional and local geology and hydrogeology, and general design information and theory regarding ERH technology). The majority of the aforementioned information is provided in the Tetra Tech Foster Wheeler Statement of Work, for In-Situ Thermal Treatment Pilot Test, NWIRP, Bedford Massachusetts, July 2002 (TTFW, 2002) for the U.S Navy; the Thermal Remediation Services (TRS) System Design and Work Plan, Electrical Resistance Heating Remediation, Site 4, Bedford NWIRP, April 2003 (TRS 2003); and the ERH Site 3 Pilot Test Report, March 2004 (TRS 2004).

This report presents the results of the Site 4 ERH Extended Treatment Area in terms of the purpose of the report outlined in Section 1.1 and presents the analytical results of the samples collected prior to, during and post-remediation application. In addition, the report briefly describes the construction, installation and operations of the Site 4 ERH application. The ERH project objectives are presented in Section 2.0 and the construction, installation and operation activities are presented in Section 3.0. Section 4.0 presents the Site 4 sampling activities and analytical results. The conclusions of the Site 4 ERH Extended Treatment Area and TRS recommendations for potential follow-on activities are presented in Section 5.0. Reference Materials are presented in Section 6.0. The figures and drawings associated with the pilot test are presented at the end of the report. Laboratory results and associated tables are presented in Appendix A. Field forms such as Monitoring Well Construction Completion Reports developed by ENSR are provided in Appendix B. Comprehensive temperature data has been tabulated and is presented in Appendix C.

2.0 SITE 4 ERH EXTENDED TREATMENT AREA OBJECTIVES

The Site 4 ERH remediation objective in the following sections is summarized from the TTFW Statement of Work (2002) and the TRS Work Plan (2003). The ERH Site 3 Pilot Test conducted by TRS is also briefly summarized in this section (and as appropriate in other sections of this report based upon relevance to the subject matter); however, complete details regarding the Site 3 pilot test scope of work, project objectives and performance goals, operations, and results have been provided in a separate Site 3 ERH Pilot Test Report submitted to TTFW for review in March 2004.

2.1 ERH OBJECTIVE

The sole objective of the Site 4 ERH remediation was to reduce benzene concentrations in groundwater within the treatment area to 50 μg/L (refer to Figure 3 for treatment area location). The objective was presented in Section 1.3.1 of the TTFW Statement of Work, (TTFW 2002). The Site 4 ERH remediation project was planned for either consecutive or concurrent operations with regards to the Site 3 ERH Pilot Test.

2.2 EXTENDED ERH TREATMENT AREA DESIGN

The design of the Site 4 ERH remediation was based on several factors including treatment area and volume, site-specific geology and hydrogeology, and the project objective. The original proposed treatment area and subsurface depth interval was based on information presented in the TTFW Statement of Work (TTFW 2002). The area designated for the Site 4 ERH remediation was based on the analytical results of previous investigations at the Bedford NWIRP. Based on this information, TRS provided TTFW with an ERH design and work plan specific to the project objective presented in the TTFW Statement of Work. The original Work Plan presented a design for Site 4 that would remediate an area approximately 20 feet wide by 36 feet long with a subsurface treatment interval of 9.5 feet to 28 feet bgs.

The TTFW proposed treatment length of 30 feet long was extended to 50 feet long based on groundwater concentrations of benzene detected in an upgradient well, MW-65S, during the baseline groundwater sampling in June 2003. The extension was approved by TTFW based on the pre-ERH remediation application data and a letter from TRS stating the need for complete remediation of the impacted area at Site 4 and recommending the aforementioned expansion of the treatment area. TRS also indicated that a more complete delineation of the remediation area was necessary to avoid potential recontamination of the site from untreated soil and groundwater. The letter from TRS has been included in Appendix B of this report since it pertains to modifications in the originally proposed treatment area. The actual operational treatment area is shown on Figure 3 which details the location of the eight electrodes installed at the site as well as the original proposed treatment boundary (TTFW 2002; TRS 2003).

As previously indicated, the length of the treatment area was extended to 50 feet resulting in an ERH application treatment volume of 19,425 cubic feet (ft^3) or approximately 719 cubic yards (yd^3). In order to remediate this area, the TRS Site 4 ERH remediation design incorporated the installation of eight electrodes with co-located vapor recovery systems as shown in Figure 4: Subsurface Component Construction Details), as well as the installation of three temperature monitoring points (TMPs) to monitor and record subsurface temperature during ERH operations.

While the Site 4 ERH remediation system was provided energy via the PCU located at Site 3, there was a separate ERH condenser unit located at Site 4. The effluent vapors, condensation and recovered groundwater were run through the Site 4 condenser as well as the four granular activated carbon (GAC) vessels located at Site 3 to treat vapors recovered by both the Site 4 ERH remediation and the Site 3 pilot test vapor recovery systems (TRS 2003, TTFW 2002).

As detailed in the TRS Work Plans for Site 4 and Site 3, the ERH system essentially heats the subsurface to temperatures necessary to volatize the contaminants of concern (TRS 2003). For ease of reference, Table 1 from the TRS Work Plan has been repeated in this document to provide information regarding the boiling point distribution at depths corresponding to the treatment intervals at Site 4 (Heron, et al, 1996).

Table 1: Boiling Points for Groundwater and Contaminants of Concern

Compound	Boiling Temperature of Compound in degrees Celsius (^{o}C) In Various Medium		
	Air	Water	
		(18-feet bgs)	(28-feet bgs)
Pure water	100	100	109
benzene	80	69	77
toluene	111	84	91
ethylbenzene	136	89	97
xylene	140	92	100

2.2.1 ERH Remediation Planned Performance Period

Based on the information summarized in Section 2.2, the Site 4 ERH remediation application was designed and planned to provide ERH for approximately 30 days to achieve the project objective set forth by the TTFW Statement of Work and the TRS Work Plan. Since the Site 4 ERH application was operated in conjunction with the Site 3 ERH Pilot Test via the same PCU and the majority of the power input was directed toward Site 3, the pilot test operations would essentially dictate the overall operational period for the Site 4.

2.3 ERH PILOT TEST AT SITE 3

The installation and operation of the Site 4 ERH remediation was predicated on the approved installation and operation of an ERH pilot test at Site 3. The Site 4 ERH application was implemented to take advantage of the available power source (and personnel) at Site 3. The Site 3 ERH Pilot Test results and details regarding subsurface installations and ERH operations were addressed in a final report submitted to TTFW in April 2004. Discussion of the Site 3 ERH Pilot Test within this document is limited to ERH power output and a discussion of the soil vapor recovery rates.

The Site 3 ERH Pilot Test was conducted at a previously-delineated source area near the Chemical Storage Building and Components Laboratory to evaluate ERH as a viable full-scale remediation technology for removing volatile organic compounds (VOCs) from soil and groundwater. The goal of the Site 3 ERH Pilot Test was to apply electrical energy to the subsurface in order to raise subsurface temperatures to a sufficient level to volatilize, and subsequently recover, VOCs; thereby reducing total VOC concentrations in the groundwater by at least 95 percent. The pilot test, located approximately 50 feet north of the Components Laboratory, was designed to treat the subsurface interval from 20 to 55 feet below ground surface (bgs). A total of 24 electrodes with co-located vapor recovery wells were installed to a depth of 60 feet bgs (i.e., five feet beyond the bottom of the treatment interval).

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3.0 SITE 4 ERH REMEDIATION SYSTEM INSTALLATION

The following sections will briefly discuss in the Site 4 ERH remediation system construction and installation activities, as well as the mobilization and demobilization tasks which include the PCU from Site 3. The details regarding the system design of the various ERH components including the PCU, condenser and vapor recovery system are provided in the TRS Work Plan under their respective section headings (TRS 2002). Only modifications to the ERH design detailed in the TRS Work Plan will be presented in this report; otherwise the reader is directed to reference the aforementioned plan for specific details regarding the ERH system components, including the subsurface installation.

In general, the Site 4 ERH remediation system included eight electrodes and three TMPs with individual thermocouple points at five-foot depth intervals from 5 feet bgs to 30 feet bgs, as well as the necessary chlorinated poly vinyl chloride (CPVC) piping (temperature/chemical-resistant material) for vapor recovery. Power was supplied to the Site 4 electrodes from the PCU at Site 3 via individual 350 MCM power cables.

3.1 ERH MOBILIZATION AND DEMOBILIZATION

As detailed in the Site 3 ERH Pilot Test report, drilling, construction and installation of the ERH system for Site 3 and Site 4 began in early spring 2003 and was completed during that summer. The ERH PCU arrived at the Bedford NWIRP on April 4, 2003, while the remainder of the ERH process equipment arrived on April 30 and May 1, 2003 (TRS Pilot Test Report 2004).

Demobilization activities, including decommissioning and decontaminating ERH pilot test equipment, were initiated on November 10, 2003 and completed on November 14, 2003. The Site 3 and Site 4 ERH condensers, including the cooling towers, as well as the piping from the vapor recovery and drip systems, were decontaminated using a pressure washer. All of the decontamination water and other waste associated with decontamination activities was collected and stored in drums on site for disposal by TTFW. The granular activated carbon (GAC) vessels used during the pilot test and Site 4 operations, as well as the remaining carbon filter replacement sacks, were removed by the vendor, US Filter-Westates. The thermocouples used to monitor subsurface temperatures were disconnected from the automated monitoring system, labeled, and left in place for further monitoring via a hand-held meter by TTFW during the post-treatment cool down period at Site 3 and Site 4 (TRS Pilot Test Report 2004).

3.2 ERH PILOT TEST INSTALLATION AND CONSTRUCTION ACTIVITIES

3.2.1 Drilling Activities and Schedule

Drilling activities for the Site 4 ERH Remediation began May 13, 2003, and were completed on July 21, 2003. The drilling service provider, Bowser-Morner of Dayton, Ohio, used a sonic drill rig to advance the boreholes for the eight electrodes, three TMPs, and nine monitoring wells as specified in the TRS Work Plan (TRS 2003). The monitoring well installation, supervised and logged by a geologist from TTFW, was completed on May 18, 2003. The installation of the electrodes, TMPs and monitoring wells associated with Site 3 superceded the installation of the remaining subsurface components at Site 4. After completing installation of the Site 3 ERH pilot test subsurface components, the remaining electrodes and TMPS were constructed and installed at Site 4 by July 21, 2003.

<u>Site Survey</u>

All of the subsurface installation points, including the electrodes and TMP locations, were located at the site using handheld tape measurements and existing structures as benchmarks. The electrode and monitoring well locations were selected and located in the field according to the design layout in the TRS Work Plan and subsequent modifications based on the extension of the treatment area at Site 4 (TRS 2003). The installed electrode, TMP and monitoring well locations are presented in Figure 3: Site 4 ERH Extended Treatment Area.

As of the date of this report, a site survey has not been completed. The site survey of all locations at the two ERH sites will be completed by TTFW. Figures associated with this report will be updated accordingly and submitted as amendments when the survey information is available.

3.2.2 Electrode Installation

The eight electrodes were located at Site 4 as shown on Figure 3 and installed to a depth of 30 feet bgs. Each electrode was constructed and installed in a 12-inch borehole per the construction specifications shown on Figure 4: ERH Electrode, TMP and Monitoring Well Construction Details in this report and as detailed in the TRS Work Plan (TRS 2003). According to the TRS design specifications for the Site 4 ERH remediation, the electrode boreholes were spaced on 13 foot centers from other electrodes (refer to Figure 3 for the treatment area plot plan).

3.2.3 Co-located Vapor Recovery Wells and Piping

A vapor recovery well (VR well) was co-located with each electrode as shown on Figure 4 of this document and per the design specifications of the TRS Work Plan (TRS 2003). The VR well screen intervals for the Site 4 ERH remediation were installed from 10 to 30 ft bgs with conductive material backfill in the annulus. The vapor recovery piping was installed above grade as shown on the plot plan Figure 3 and vapor recovery flow was controlled by a 1.5-inch ball valve installed at each electrode/VR well recovery header. Ports for measuring vacuum, flow, and concentration, as well as a thermocouple, were also installed in the above-grade piping at each electrode/VR well location to enable measurement of vapor recovery parameters (i.e., flow rate, temperature, and pressure).

3.2.4 Temperature Monitoring Points

The TMPs for the pilot test were installed according to the TRS Work Plan to a depth of 30 feet bgs to enable remote monitoring and recording of subsurface temperatures during operations. As shown on Figure 3, the three TMP locations were located inside the ERH treatment region to monitor the subsurface treatment temperatures (TRS Work Plan 2003). The TMP-1 and -2 locations were situated within the treatment area, essentially surrounded by electrodes. The remaining location, TMP-3 as shown on Figure 3, was located along the western boundary of the Site 4 ERH remediation to provide some documentation regarding the extent of subsurface heating along the periphery of the treatment area.

As specified in the TRS Work Plan and shown on Figure 4 of this document, 6 Type-T thermocouples were installed within each TMP borehole (TRS Work Plan 2003). All of the thermocouples were connected to a field instrument box which transferred the subsurface temperature data to the ERH PCU computer via fiber optic cable for continuous data collection and real-time system monitoring.

3.2.5 Power Control Unit

As stated in Section 3.1, the PCU was delivered to Site 3 at the Bedford NWIRP on April 4, 2003. Details regarding the installation of the PCU are provided in the April 2004 Site 3 ERH Pilot Test Report. The location of the PCU within the process treatment system is identified on Figure 2 and Figure 5: ERH Process Flow Diagram/Piping and Instrumentation Diagram.

The existing electrical feed (a 13.2 kilovolt (kV) power source) for the Components Building at Site 3 was utilized to provide electrical service to the PCU. The electrical service was routed to the PCU via the line side of the main facility step-down transformer at the rear of the building which eliminated the need for a new and separate electrical service to provide electrical power to the PCU, which in turn, provided an electrical power source for ancillary processing equipment.

3.2.6 ERH Process Treatment Equipment

The Site 4 ERH remediation had a separate condenser with a cooling tower, as well as a separate liquid GAC vessel, which was connected to the process treatment equipment at Site 3 (refer to Figures 2 and 5 for details). The process treatment equipment at Site 3 included a 40 horsepower (hp) blower for vapor recovery and four vapor GAC vessels (refer to Figure 5). The combined outlet of the secondary GAC vessels was connected to the blower inlet which was connected to the atmosphere discharge stack. Sampling ports and gauges were supplied to measure vacuum and flow at the blower inlet and temperature at the blower outlet. Vapor recovery from Site 3 and Site 4 was processed through the same GAC vessels; however the effluent lines from each site to the ERH process treatment equipment had sample ports allowing for the differentiation of effluent recovery rates and concentrations between Site 3 and Site 4.

3.2.7 Monitoring Wells

The scope of work for the Site 4 ERH remediation included the installation of nine monitoring wells for collecting groundwater samples to monitor the contaminant concentrations within the treatment area and to ensure that the benzene concentration remediation objective was achieved at the end of operations. In addition to the installation of the new monitoring wells at Site 4, existing monitoring well locations MW-18 and MW-42 were abandoned and replaced with new wells constructed using temperature-resistant material. The same well identification was kept for consistency, but an "R" was added to indicate a replacement well.

The monitoring wells at Site 4, consisting of carbon steel riser pipes (blanks) and stainless steel screens, were installed under TTFW supervision. The location of the monitoring wells was based on the TTFW Statement of Work and the TRS Work Plan (TTFW 2002 and TRS 2003). As briefly discussed in the Site Survey subsection in Section 3.2.1 of this report, the monitoring well locations were identified at the site based on field measurements during pre-construction activities. The following monitoring well construction table, Table 2: Site 4 Monitoring Well Construction Information, is based on the field logs completed during installation by TTFW. Copies of the Monitoring Well Completion Reports are presented in Appendix B of this report.

Monitoring well development activities were also completed by TTFW. Information regarding the well volumes purged from each monitoring well, as well as the monitoring well development methods (e.g., surge block, pump, turbidity standards, etc) is available through TTFW, but has not been included in this report.

Table 2: **Site 4 Monitoring Well Construction Information**

Monitoring Well Location	Northing	Easting	Top of Casing Elevation (Flushmount)	Well Screen (0.010 Slot) Interval (feet bgs)		Casing Diameter	Total Borehole Depth (feet bgs)	Borehole Diameter (inches)
				Top	Bottom			
MW-18SR	NA	NA	NA	18	28	2-inch	28	6
MW-42SR	NA	NA	NA	15	25	2-inch	25	6
MW-60S	NA	NA	NA	16	26	2-inch	27	6
MW-61S	NA	NA	NA	15	25	2-inch	26	6
MW-62S	NA	NA	NA	16	26	2-inch	27	6
MW-63S	NA	NA	NA	14	24	2-inch	25	6
MW-64S	NA	NA	NA	14	24	2-inch	25	8
MW-65S	NA	NA	NA	13	23	2-inch	24	6
MW-66S	NA	NA	NA	9	19	2-inch	24	6

Information is based on Tetra Tech Foster Wheeler Monitoring Well Construction Detail Reports.
NA: Not available at this time (see Site Survey subsection of Section 3.2.1 of this report for details); R: replacement.

4.0 SITE 4 ERH REMEDIATION

The following sections discuss the ERH operations and present the data collected from operational monitoring. All operations-related activities specific to the ERH system, including systems monitoring, maintenance and repair, were conducted by TRS site operations personnel. The data presented in the following sections, such as power input and subsurface temperatures, was primarily derived from automatic sensing equipment associated with the ERH system.

4.1 SYSTEM START UP AND INTERLOCK TESTING

As detailed in the Site 3 ERH Pilot Test Report, power was supplied to all of the ERH system components, including the electrodes, during the startup and testing shakedown period. Prior to applying power to the treatment volume, TRS site operations personnel completed various forms including an ERH Startup Checklist, ERH PCU Checklist, and a Component/Interlock Test form which are provided in Appendix B of the April 2004 Site 3 ERH Pilot Test Report. The startup testing, which included current and voltage surveys, was performed to ensure the safety of those working around the ERH equipment, and to verify the proper operation of the ERH system safety interlocks and emergency shutdown control systems. Greater details regarding the start up testing procedures are provided in the April 2004 Site 3 ERH Pilot Test Report and the April 2003 TRS Work Plan.

4.2 ERH REMEDIATION OPERATIONS

The operations phase of the Site 4 ERH remediation began in conjunction with the Site 3 ERH Pilot Test on July 31, 2003. The pilot test at Site 3 was officially completed on September 22, 2003, resulting in an operational period of 53 days. Consequently, operations at Site 4 also ceased on September 22, 2003, based on the official shutdown of ERH operations at the NWIRP, as well as groundwater data which indicated that benzene concentrations were below the remediation goals at all monitoring well locations within the Site 4 treatment area.

The treatment area average subsurface temperature increased from an ambient subsurface temperature of 14 ºC prior to operations to a daily site average ranging from 88 ºC to 93 ºC for the week ending September 22, 2003 (based on the overall temperature average of the three TMPs within the treatment area). Cumulative energy input for both the Site 3 Pilot Test and the Site 4 Remediation totaled 726,391 kW-hr, with approximately 23 percent, or about 167,070 kW-hr, applied directly to Site 4 ERH remediation.

4.2.1 Site 4 and Site 3 ERH Power Ratio

Power was simultaneously applied to the Site 4 ERH remediation application and the Site 3 ERH Pilot Test by the TRS PCU. As detailed in the Site 3 ERH Pilot Test Report, the initial percentage of power applied to the Site 4 remediation was approximately eight percent, while the remaining 92 percent was applied to the Site 3 pilot test. The lowering of the water table at Site 3, though, resulted in a 14 percent change in the ratio of power input to either site (i.e., decreased power to Site 3 and increased power to Site 4). The ratio of power input to each site was extrapolated based on the current surveys conducted by site operations personnel and the total energy input applied by the PCU.

Due to its location (i.e., lower on the northern slope and subject to higher rate of groundwater recharge) and the lower power input, Site 4 did not experience the water table elevation decreases observed at Site 3. Consequently, Site 4 was able to maintain a higher level of electrical conductivity and higher electrical current flow.

4.3 VAPOR RECOVERY SYSTEM

Vapor recovery during the Site 4 ERH remediation was achieved via the 40-hp rotary lobe blower and the eight co-located VR wells within each electrode borehole (refer to Figures 5 and 4 for process flow and electrode/VR well construction details). In addition, vapor recovery was also performed at the Site 3 ERH Pilot Test using the 24 co-located electrode/VR wells. Both sites were operated simultaneously and used the same 40-hp blower, as well as the four vapor phase GAC vessels for vapor treatment.

Site personnel for TTFW provided the staffing for collection of vapor recovery flow rates using a hot-wire anemometer, as well as vapor recovery system pressure and temperature readings in the independent four-inch conveyance lines from Site 3 and Site 4. A table of vapor recovery flow rate data for the two ERH sites, as well as collection dates is provided in Appendix A of this report. The table also provides the calculation for conversion to standard cubic feet per minute (scfm) from actual cubic feet per minute (acfm) provided by the hot wire anemometer.

A comparison between the Site 4 ERH remediation and the Site 3 ERH Pilot Test vapor recovery systems is provided in the following table.

Table 3: Average Soil Vapor Recovery Flow Rate for the Site 4 and Site 3 Pilot Test Period

Site Location and Specifications	August 1, 2003	September 16, 2003	Average Vapor Recovery Flow Rate[a]
Site 3 Vapor Recovery Flow Rate(scfm)	57	52	49
Site 4 Vapor Recovery Flow Rate(scfm)	178	36	138
TRS Work Plan Vapor Recovery Flow Rate (scfm) Estimate (April 2003)	480		

a: Average recovery flow rate is based on 25 sample collection dates; see table in Appendix A.

The GAC units previously described in Section 3.2.6 of this report were changed once during the ERH operations, on September 5, 2003. The spent primary GAC was returned to US Filter Westates and the secondary units were moved into the primary position. Fresh carbon sacks were subsequently replaced in the secondary unit containers.

4.3.1 Condensate Production

As previously stated in Section 4.2, steam and condensate removal from July 31, 2003 through September 19, 2003 (last reading available prior to the official completion of the pilot test on September 24, 2003), resulted in a condensate production of 7,526 gallons of water from Site 4. The average removal rate for condensate based on the totalizer readings over time was approximately 0.1 gpm. The vapor recovery system continued operating until October 10, 2003, resulting in an additional removal of approximately 994 gallons of condensate (active steam production ceased on September 22, 2003, shortly after the cessation of power input to the treatment area). As stated earlier, site operations personnel noted a problem with the condensate totalizer readings on September 16, 2004, due to sand in the line, which was subsequently removed. All the condensate produced during ERH operations was treated with liquid GAC prior to being reinjected in to the electrodes.

4.4 SUBSURFACE TEMPERATURES

The average subsurface temperature from 10 to 25 feet bgs within the ERH treatment area prior to the start of operations was 14 ^{o}C based on TMP locations -1, -2 and -3. As shown on Figure 6: Site 4 Temperature Results Per TMP Locations, appropriate boiling point temperatures for

benzene between 18 and 28 feet bgs (approximately 69 to 77 ^{o}C according to Table 1 in this report) were achieved during the last week of August at TMP locations -1 and
-2 and on September 15, 2003 at TMP-3. The Site 4 average subsurface temperature reached an operational high of 93 ^{o}C from September 16, 2003 through September 22, 2003. The daily site average temperature ranged from 88 to 93 ^{o}C during that period.

4.4.1 Site 4 Average Subsurface Temperatures

Subsurface temperatures were monitored continuously and recorded daily at each TMP location (refer to the TRS Work Plan 2003 for operational details). As shown on Figure 4 of this report, thermocouples were installed at five-foot intervals from five to 30 feet bgs resulting in a total of six thermocouples (subsurface temperature monitoring points) within each TMP location. The treatment interval for the Site 4 ERH remediation application was 9.5 to 28 feet bgs in accordance with the TRS Work Plan and the TTFW Statement of Work (TRS 2003 and TTFW 2002). The electrode conductive interval, as shown on Figure 4, was from 9.5 feet to 30 feet bgs.

The overall weekly average for each temperature monitoring interval on August 27, 2003 and September 20, 2003 is provided in Table 4: ERH Remediation Temperature Results per TMP Location. The dates selected essentially reflect the middle of the operational period and the documented highest daily average for subsurface temperatures several days before ERH power was shutdown (the official completion of the Site 3 pilot test was on September 24, 2004, however, ERH power input ceased on September 22, 2004 due to a system interlock shutdown).

It should be noted that TMP-3 was located at the perimeter of the target treatment area, and therefore was not subjected to strong active heating. This resulted in lower peak temperatures being achieved at this TMP location. The temperature increase at specific depth intervals (5 to 30 feet bgs) for each TMP location at Site 4 for the duration of the ERH remediation application is presented in Figures 7 through 9.

Table 4: ERH Remediation Temperature Results Per TMP Location

TMP Location	Date (Week Ending)	Average Temperature for Treatment Interval (^oC)	Subsurface Interval Temperature Average (feet bgs/^oC)					
		10-28 ft	5	10	15	20	25	30
TMP-1	08/27/03	68	37	40	58	83	89	67
	09/20/03	94	36	74	99	99	99	95
TMP-2	08/27/03	83	45	44	84	101	104	71
	09/20/03	100	55	85	101	101	101	86
TMP-3	08/27/03	49	37	30	38	60	67	48
	09/20/03	85	45	59	94	86	81	62

Temperature data has been rounded to nearest whole number

As shown in Table 4, there was some fluctuation in temperatures at the various subsurface intervals, however, by September 17, 2003, the average TMP temperature for the ERH application treatment interval (10 to 30 feet bgs) exceeded 90 ^oC at TMP location -1 and -2 and exceeded 80 ^oC at TMP-3. According to the information provided in Table 1, 80 ^oC was above the boiling point for benzene at depth.

The lower subsurface temperatures exhibited at TMP-3, though registering temperature levels necessary to boil benzene, were due to its location on the periphery of the Site 4 treatment area. The other TMP locations, -1 and-2, were located as shown on Figure 3 within close proximity to the center of the treatment area and, consequently, essentially surrounded by ERH electrodes.

Personnel from TTFW continue to measure water levels and subsurface temperatures at Site 3 and Site 4 at the Bedford NWIRP. Graphic representations of the average subsurface temperature decrease per TMP location for Site 4, as well as the predicted trend line for temperature decrease over time, are provided in Figures 10 and 11, respectively. Complete data tables for recorded temperature intervals recorded by TRS prior to, during and after the completion of the ERH remediation are provided in Appendix C.

5.0 SAMPLING ACTIVITIES AND ANALYTICAL RESULTS

The following sections discuss the field sampling activities and present the analytical results for the Site 4 ERH remediation application. The sampling activities conducted prior to, during and after the ERH application and the analytical results provided information to monitor the reduction of BTEX concentrations, specifically benzene (cleanup goal specified by the 2002 TTFW Statement of Work as 50 μg/L).

Sampling events included the collection of groundwater samples from select monitoring wells at the site, as well as the collection of influent vapor samples from Site 3 and Site 4 prior to the GAC inlet; and GAC effluent vapor samples. All sampling activities including field logs, sample collection sheets, as well as sample packaging and shipping were conducted by TTFW personnel, except for the pre-ERH remediation groundwater samples which were collected by Tetra Tech NUS. The tables included within this section of the report were developed by TRS based on sample report information presented by TTFW.

For reference, the available analytical data from the offsite laboratories for the Site 4 remediation are located in Appendix C of this report.

5.1 GROUNDWATER SAMPLING

In accordance with the TRS Work Plan, groundwater sampling events for the Site 4 ERH remediation were conducted prior to, during and after the completion of operations at Site 4 (TRS 2003). The groundwater samples were collected in an effort to monitor the progress of the benzene concentration reduction toward the cleanup goal of 50 μg/L established by the TTFW Statement of Work (TTFW 2002). Cleanup goals were not established for the remaining BTEX constituents (toluene, ethylbenzene and xylene) and, therefore, those constituents are not addressed in this document.

The collected groundwater samples were shipped to an offsite laboratory for VOC analysis using USEPA SW 846 Method 8260a.

Field Sampling Methodology

As detailed in the TRS Work Plan and shown on Figure 12: Monitoring Wellhead Sample Collection Configuration, groundwater samples collected via a peristaltic pump were processed through a stainless steel coil immersed in an ice bath to effectively cool the sample water down to safe handling levels and further minimize any volatilization loss associated with agitation of the groundwater during the sample process (TRS 2003).

As indicated in the late September and early October 2003 Sample Collection Field Sheets maintained by TTFW personnel and presented in Appendix B of this report, some well locations experienced slow recharge and occasionally dried out during the low flow sample purging process. The reduced yield from ground water monitoring wells observed in the Site 4 monitoring well locations should be attributed to the aforementioned slow recharge and not equated with the decreased water table documented at Site 3 (please refer to the April 2004 Site 3 ERH Pilot Test Report for greater details).

5.1.1 Data Validation

Any data validation of the sample results was the responsibility of TTFW and has not been included in this report, other than laboratory qualifiers. The laboratory results presented in this section of the report and in Appendix A have been assigned data qualifiers by the offsite laboratory. The following laboratory-assigned qualifier codes appear in connection with the analytical results presented in Section 5.0 of this report:

Qualifier Code	Explanation
U	Not Detected; Detection Limit Listed
J	Quantification Approximate
E	Estimated Value
Other Notes Assigned to Analytical Results	
ND	Not Detected; Detection Limit Unknown
NA	Not Available

The analytical results tables presented in Section 5 have been reproduced and summarized from tables within Appendix A of this document.

5.1.2 Analytical Results for Site 4 Groundwater Samples

The following tables present the analytical results for the groundwater sampling events conducted prior to, during and after the ERH remediation application at Site 4 for each monitoring well location. Each table presents a separate groundwater sampling event as well as the baseline value for comparison.

The analytical results for the BTEX analyzed via a gas chromatograph/mass spectrometer (GC/MS) have been summarized within this section of the report in order to minimize the size of the tables. A full accounting of all VOCs analyzed per monitoring well location and sample collection date is provided in Appendix A of this report. Values shown in bold represent detections of BTEX constituents during that sample collection event. Other necessary information has either been presented in a regular font or gray-scale to minimize complexity of the tables. In most cases, samples results were based on two dilution factors. While all of the available data from the laboratories has been provided in this report, TRS has only tabulated on set of data (i.e., the initial sample analysis).

5.1.3 Pre-ERH Remediation Analytical Results for Site 4 Groundwater Samples

Baseline groundwater samples prior to the start of operations at the two ERH sites (July 31, 2003) were collected by TTFW in May and June of 2003 (see table for specific sample collection dates).

Table 5: Pre-ERH Remediation May and June Baseline Sampling and Analytical Results

May and June 2003 Groundwater Sample Event Dates (Site 4 Pre-ERH Remediation)								
Treatment Area Location	Sample Dates	Analytical Results						
		Compound						
		Units	Benzene	Toluene	Ethylbenzene	p/m-Xylene	o-Xylene	Total-Xylene
MW-18SR	6/15/2003	µg/L	**220**	**2200**	**1200**	**3600**	**1500**	**NA**
IW-5	6/30/2003	µg/L	**360**	**1400**	**800**	**1800**	**600**	**NA**
MW-61S	5/30/2003	µg/L	**76J**	**3800**	**290**	**7800**	**4800**	**NA**
MW-62S	5/29/2003	µg/L	**59**	**85**	**110**	**410**	**150**	**NA**
MW-63S	6/2/2003	µg/L	**180**	**4400**	**1600**	**8700**	**4200**	**NA**
MW-64S	5/30/2003	µg/L	**210**	**920**	**280**	**6700**	**4200**	**NA**
MW-65S	6/2/2003	µg/L	**320**	**5900**	**1500**	**6200**	**2600**	**NA**
Outside of ERH Treatment Area								
MW-42SR	6/2/2003	µg/L	**14**	**1.5J**	**34**	**22**	**1.2J**	**NA**
MW-60S	5/29/2003	µg/L	**250**	**1800**	**1600**	**3500**	**1200**	**NA**
MW-60S	5/29/03D	µg/L	**250**	**2300**	**1700**	**3800**	**1800**	**NA**
MW-66S	6/30/2003	µg/L	**52**	**24**	**210**	**130**	**43**	**NA**

Bold value indicates detected concentration; D: Duplicate sample
Grayscale represents well locations outside treatment area.

Please refer to Appendix A for complete analytical results for the baseline samples collected in May and June 2003 (Pre-ERH remediation) groundwater sampling event.

5.1.4 September Analytical Results for Site 4 Groundwater Samples

Groundwater sampling was conducted twice by TTFW during September of 2003 (see Table 6 for specific sample collection dates). As outlined in the TRS Work Plan, groundwater sample collection was planned for the 60 and 80 percent completion periods of the ERH remediation at Site 4. Based on the extended length of operations, samples were actually collected during the 75 percent completion period of the ERH Remediation.

As shown in Table 6, benzene concentrations for all sampled well locations within the treatment area were below the remediation goal of 50 μg/L. Cleanup goals were not established for the remaining BTEX constituents, however, a relatively significant (any value greater than 10 percent) decrease in groundwater concentrations for toluene, ethylbenzene and xylene is observable.

Table 6: ERH Remediation Early September Operations Sampling and Analytical Results

September (Early) 2003 Groundwater Sample Event Dates (Site 4: 75 percent ERH Remediation)									
Treatment Area Location	Sample Dates	Analytical Results							
		Compound							
		Units	Benzene	Toluene	Ethylbenzene	p/m-Xylene	o-Xylene	Total-Xylene
MW-65S	6/2/2003	μg/L	320	5900	1500	6200	2600	NA
	9/9/2003	μg/L	**18J**	**600**	**420**	**1800**	**910**	**NA**
MW-65D	9/9/2003	μg/L	**14J**	**520**	**370**	**1600**	**780**	**NA**
MW-63S	6/2/2003	μg/L	180	4400	1600	8700	4200	NA
	9/9/2003	μg/L	**10U**	**14**	**6.0J**	**31**	**7.0J**	**NA**
MW-18SR	6/15/2003	μg/L	220	2200	1200	3600	1500	NA
	9/9/2003	μg/L	**2.0U**	**6.8**	**3.1**	**18**	**2.7**	**NA**
Remediation Goal		μg/L	50	NE	NE	NE	NE	NE

Bold value indicates detected concentration; values in gray represent baseline data.
NE: Not established

Please refer to Appendix A for complete analytical results for the early September 2003 (75 percent ERH remediation) groundwater sampling event.

5.1.5 Post-ERH Remediation Analytical Results for Site 4 Groundwater Samples

Post-ERH remediation application groundwater sampling was conducted by TTFW during late September and early October of 2003 (see Table 7 for specific sample collection dates) and again in April 2004. As outlined in the April 2003 TRS Work Plan, post-Site 4 operations groundwater sample collection events were planned to evaluate the effectiveness of the ERH remediation application and to monitor any potential recontamination of the treatment area from potential upgradient sources.

5.1.5.1 Site 4 Late September and Early October Groundwater Sample Results

As shown on Table 7, benzene concentrations remained below the Site 4 ERH remediation cleanup goal of 50 μg/L during the September 29 through October 1, 2003 sampling event. Monitoring well location MW-62S was flagged with a laboratory qualifier for an estimated value above the remediation cleanup goal, however, as shown in the April 2004 sampling results in the next section, MW-62S benzene concentration was reported at 3.4 μg/L.

Table 7: Initial Post-ERH Remediation Sampling and Analytical Results

Late September and Early October 2003 Groundwater Sample Event Dates (Site 4 Post-ERH Remediation)								
Treatment Area Location	Sample Dates	Analytical Results						
		Compound						
		Units	Benzene	Toluene	Ethylbenzene	p/m-Xylene	o-Xylene	Total-Xylene
MW-18SR	6/15/2003	μg/L	**220**	**2200**	**1200**	**3600**	**1500**	**NA**
	9/30/2003	μg/L	**3.3J**	**24**	**15**	**64**	**40**	**NA**
MW-61S	5/30/2003	μg/L	**76J**	**3800**	**290**	**7800**	**4800**	**NA**
	9/30/2003	μg/L	**14J**	**830**	**650**	**4700E**	**2600E**	**NA**
MW-62S	5/29/2003	μg/L	**59**	**85**	**110**	**410**	**150**	**NA**
	10/2/2003	μg/L	**66J**	**230**	**790**	**2000**	**710**	**NA**
MW-63S	6/2/2003	μg/L	**180**	**4400**	**1600**	**8700**	**4200**	**NA**
	10/1/2003	μg/L	**20U**	**27**	**25**	**62**	**24**	**NA**
MW-64S	5/30/2003	μg/L	**43**	**920**	**280**	**6700**	**4200**	**NA**
	9/30/2003	μg/L	**32J**	**1000**	**1000**	**4900**	**2600**	NA
MW-65S	6/2/2003	μg/L	**320**	**5900**	**1500**	**6200**	**2600**	**NA**
	9/30/2003	μg/L	**6.2J**	**81**	**78**	**330**	**120**	**NA**
Outside of ERH Treatment Area								
MW-42SR	6/2/2003	μg/L	**14**	**1.5J**	**34**	**22**	**1.2J**	**NA**
	9/30/2003	μg/L	**20**	**7.4J**	**65**	**71**	**18**	**NA**
MW-60S	5/29/2003	μg/L	**250**	**1800**	**1600**	**3500**	**1200**	**NA**
	9/29/2003	μg/L	**140**	**670**	**2100**	**4600**	**1100**	**NA**
MW-66S	6/30/2003	μg/L	**52**	**24**	**210**	**130**	**43**	**NA**
	10/1/2003	μg/L	**32**	**91**	**26**	**260**	**93**	**NA**
MW-66SD	10/1/2003	μg/L	**32**	**86**	**26**	**250**	**90**	**NA**
Remediation Goal		μg/L	50	NE	NE	NE	NE	NE

Bold value indicates detected concentration; values in gray represent baseline data and locations outside of the treatment area. NE: Not established

Please refer to Appendix A for complete analytical results for the initial September and October post-ERH remediation groundwater sampling event.

5.1.5.2 Site 4 April 2004 Groundwater Sample Results

As shown on Table 8, benzene concentrations remained below the Site 4 ERH remediation cleanup goal of 50 μg/L during the April 2004 sampling event.

Table 8: April 2004 Post-ERH Remediation Sampling and Analytical Results

April 2004 Groundwater Sample Event Dates (Site 4 Post-ERH Remediation)								
Treatment Area Location	Sample Dates	Analytical Results						
		Compound						
		Units	Benzene	Toluene	Ethylbenzene	p/m-Xylene	o-Xylene	Total-Xylene
MW-18SR	6/15/2003	μg/L	**220**	**2200**	**1200**	**3600**	**1500**	**NA**
	4/14/2004	μg/L	41	12	650	800	43	NA
MW-61S	5/30/2003	μg/L	**76J**	**3800**	**290**	**7800**	**4800**	**NA**
	4/13/2004	μg/L	2.0U	2.0U	2.0U	34	16	NA
MW-62S	5/29/2003	μg/L	**59**	**85**	**110**	**410**	**150**	**NA**
	4/13/2004	μg/L	3.4	17	12	47	20	NA
MW-62SD	4/13/2004	μg/L	3.5	17	12	48	19	NA
MW-63S	6/2/2003	μg/L	**180**	**4400**	**1600**	**8700**	**4200**	**NA**
	4/14/2004	μg/L	26	27	480	1300	290	NA
MW-64S	5/30/2003	μg/L	**43**	**920**	**280**	**6700**	**4200**	**NA**
	4/14/2004	μg/L	4.4	13	130	1100	260	NA
MW-65S	6/2/2003	μg/L	**320**	**5900**	**1500**	**6200**	**2600**	**NA**
	4/14/2004	μg/L	40	250	280	650	400	NA
Outside of ERH Treatment Area								
MW-42SR	6/2/2003	μg/L	**14**	**1.5J**	**34**	**22**	**1.2J**	**NA**
	4/13/2004	μg/L	**2.2**	**2.0U**	**15**	**14**	**2.0U**	**NA**
MW-60S	5/29/2003	μg/L	**250**	**1800**	**1600**	**3500**	**1200**	**NA**
	4/14/2004	μg/L	**7.6**	**1.3J**	**97**	**26**	**6.5**	**NA**
MW-66S	6/30/2003	μg/L	**52**	**24**	**210**	**130**	**43**	**NA**
	4/13/2004	μg/L	**91**	**46**	**240**	**190**	**88**	**NA**
Remediation Goal		μg/L	50	NE	NE	NE	NE	NE

Bold value indicates detected concentration; values in gray represent baseline data and locations outside of the treatment area. NE: Not established

The April 2004 analytical results for benzene indicate a rise in concentration at several treatment area monitoring well locations; however the concentrations are still below the 50 μg/L remediation goal. Based on the increased benzene concentration at monitoring well MW-66S, located outside of the Site 4 treatment region, as well as the initial high level of benzene concentrations in the baseline samples, it is presumable that recontamination of the monitoring wells is attributable to groundwater flow from source area(s) within close proximity to Site 4 that were not within the ERH remediation boundaries.

Please refer to Appendix A for complete analytical results for the April 2004 post-ERH remediation groundwater sampling event.

5.2 VAPOR SAMPLING

In accordance with the TTFW Statement of Work and the TRS Work Plan, vapor sampling of the influent vapor samples from Site 4 and Site 3 prior to the GAC inlet and at the GAC effluent were conducted by TTFW immediately prior to and during ERH remediation at Site 4 as well as the Site 3 pilot test to monitor the effectiveness of the ERH remediation application and the mass recovery rate (TTFW 2002 and TRS 2003). The vapor sampling was also used to determine breakthrough of the primary GAC units and for determining the appropriate time to change and dispose of the GAC filter bags.

As previously discussed in this report, the vapor recovery piping and sampling ports from each site allowed for the differentiation of the vapor samples from Site 3 and Site 4. The vapor samples were shipped to an offsite laboratory for VOC analysis using modified USEPA Method TO14A. The available laboratory reports regarding vapor analysis are provided in Appendix A.

Field Sampling Methodology

Vapor samples from both of the ERH sites' vapor recovery piping were collected on a weekly basis by TTFW using summa canisters and a flame ionization detector (FID) for determining total VOC recovery prior to the GAC inlet. Due to the reliability issues of the FID (according to TTFW site personnel who used the FID most days of the week for measuring total VOCs), only the quantifiable laboratory data in parts per million by volume (ppmv) from the summa canisters was used to extrapolate the VOC mass removal.

5.2.1 Data Validation

Any data validation of the sample results was the responsibility of TTFW and has not been included in this report, other than laboratory qualifiers. The laboratory results presented in this section of the report and in Appendix A have been assigned data qualifiers by the offsite laboratory. The laboratory-assigned qualifier codes appear in connection with the analytical results presented in Appendix A of this report:

5.2.2 Analytical Results for Site 4 Vapor Recovery

The following table presents the analytical results for the vapor recovery sampling events conducted immediately prior to and during the Site 4 ERH remediation application.

The analytical results tables presented in this section have been reproduced and summarized from tables within Appendix A of this document. The summa canisters were collected on a weekly basis by TTFW personnel from the start of the remediation on July 31, 2003 through August 28, 2003, for Site 4.

Table 9: ERH Remediation Vapor Recovery Sampling and Analytical Results

Date and Location		Compound				
		BENZENE	TOLUENE	ETHYL BENZENE	M,P-XYLENE	O-XYLENE
31-Jul-03	SITE 4 INFLUENT	92	1600	260	9200	3600
	GAC EFFLUENT	0.86 U	0.86 U	0.86 U	0.86 U	0.86 U
07-Aug-03	SITE 4 INFLUENT	12	330	66	3000	1400
	GAC EFFLUENT	0.90 U	0.90 U	0.90 U	0.90 U	0.90 U
14-Aug-03	SITE 4 INFLUENT	16.00	140.00	30.00	2300.00	1300.00
	GAC EFFLUENT	0.80 U	0.80 U	0.80 U	0.80 U	0.80 U
22-Aug-03	SITE 4 INFLUENT	32	650	170	5200	2400
	GAC EFFLUENT	33 U	33 U	33 U	33 U	33 U
28-Aug-03	SITE 4 INFLUENT	520	13000	4900	45000	16000
	GAC EFFLUENT	260 U	310 U	360 U	110	360 U

U: Not Detected; Detection Limit Used; PPBV: parts per billion by volume

The fluctuations in VOC concentrations can be attributed to the initial vapor recovery at the site during startup. The following decrease and subsequent peak BTEX concentrations reported in the early weeks of the ERH pilot test can be attributed to increased temperatures and corresponding volatilization of VOCs within the immediate vicinity of the co-located electrode/VR wells. A full accounting of all VOCs analyzed per sample collection dates is provided in tables in Appendix A of this report.

Based on the analytical vapor recovery results in conjunction with the flow rates of the vapor recovery system (measured in scfm), TTFW estimated 95 pounds of VOCs were recovered by the Site 4 VR wells from the start of operations on July 31, 2003 through September 16, 2003. The average rate of VOC removal via the vapory recover system was 2.0 pounds per day (estimated). The daily vapor flow rates and extrapolated mass removal measured and calculated by TTFW are presented in Appendix A.

5.3 REMEDIATION-DERIVED WASTE STREAM SAMPLING

All waste streams, such as water associated with drilling and decontamination, were containerized on site for sampling and disposition by TTFW. Analytical results pertaining to the aforementioned waste stream analysis are not presented in the TRS Site 4 ERH Remediation Report.

6.0 CONCLUSIONS

The Site 4 ERH Remediation was conducted in response to the TTFW Statement of Work (2002) under contract to the U.S. Navy Engineering Field Activity Northeast RAC N62472-99-R-0032, Task Order 0089. The ERH Remediation was designed, constructed and operated to reduce benzene concentrations in groundwater to a cleanup level of 50 μg/L within the treatment volume. The construction of the Site 4 ERH Remediation began in May 2003 and site ERH operations began on July 31, 2003. The official cessation of ERH operations was September 22, 2004, based on available groundwater analytical results, as well as cessation of the Site 3 ERH Pilot Test.

As shown in the data presentation in Section 5 of this report, the benzene remediation goal was achieved at all monitoring well locations within the treatment volume. The April 2004 data results indicate an increase in BTEX concentrations at several locations, including some monitoring wells within the treatment volume. While the treatment volume monitoring well groundwater results are still below the benzene remediation goal, the observed increases indicate a potential recontamination of the treatment area from an outside source location. TRS has submitted a second memorandum to TTFW on April 29, 2004, discussing this observed condition at Site 4 and potential recontamination of the site due to groundwater flow through unremediated soil located outside the ERH treatment volume.

Prior to the start of the ERH operations, the Site 4 ERH Remediation source volume was presumed to be fully delineated, however, initial baseline results of monitoring well locations beyond the periphery of the ERH treatment boundary indicated BTEX concentrations in excess of the benzene cleanup goal established in the November 2002 TTFW Statement of Work. TRS advised TTFW in a letter dated June 19, 2003, of the need for potential expansion of the ERH treatment area to adequately remediate the benzene concentrations in groundwater and to minimize or eliminate the potential for recontamination of the site based on groundwater flow through unremediated soil. The site was expanded beyond the initially proposed treatment volume, however, the baseline sample results indicated the potential for further ERH treatment volume expansion.

Both TRS memorandums have been included in Appendix B of this report.

6.1 BENZENE CONCENTRATION REDUCTION

The primary objective of the Site 4 ERH Remediation was to reduce the pre-ERH application benzene concentrations within the treatment volume to below 50 μg/L. While Site 4 was determined to be a BTEX groundwater contamination source area, the only established reduction goal was for the benzene constituent. The data presented in Section 5.0 indicates that the Site 4

ERH Remediation goal for benzene was met during the operational period from July through September 2003.

As indicated in this report, energy input via the design electrode configuration resulted in subsurface temperatures rising to a level adequate to boil benzene in groundwater (refer to Table 1 for details). Consequently, the Site 4 ERH Remediation system was successful in achieving the benzene cleanup goal. It should be noted, though, that there was significant (i.e., greater than 10 percent) reduction in all BTEX constituent concentration levels, as a result of the remediation efforts.

Since Site 4 was operated in conjunction with the Site ERH Pilot Test, the system was shutdown per the direction of TTFW on September 22, 2003. The groundwater data from Site 4 indicated that prolonged operations beyond the Site 3 ERH Pilot Test would not be necessary since benzene concentrations within the treatment volume monitoring wells were below the 50 μg/L cleanup goal.

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7.0 REFERENCES

(Heron, et al, 1996) "Temperature Effects on the Distribution of Organics in Soil and Groundwater and Implication for Thermally Enhanced In-Situ Remediation," Environmental Science Technology. December.

Tetra Tech Foster Wheeler (TTFW). 2002. Statement of Work for In-Situ Thermal Treatment Pilot Test, Naval Weapons Industrial Reserve Plant (NWIRP), Bedford, Massachusetts. July.

Thermal Remediation Services, Inc (TRS). 2003. System Design and Work Plan, Electrical Resistance Heating Remediation, Site 4, Naval Weapons Industrial Reserve Plant (NWIRP), Bedford, Massachusetts. April.

Thermal Remediation Services, Inc. 2004. Final Report, Site 3 Electrical Resistance Heating Pilot Study, Naval Weapons Industrial Reserve Plant (NWIRP), Bedford, Massachusetts. April.

DON Environmental Restoration Plan for Fiscal Years 1997-2001. Bedford Naval Weapons Industrial Reserve Plant, Bedford, Massachusetts. Executive Summary. (http://5yrplan.nfesc.navy.mil/1997) (http://5yrplan.nfesc.navy.mil/previous/mar_1997/ma.pdf)

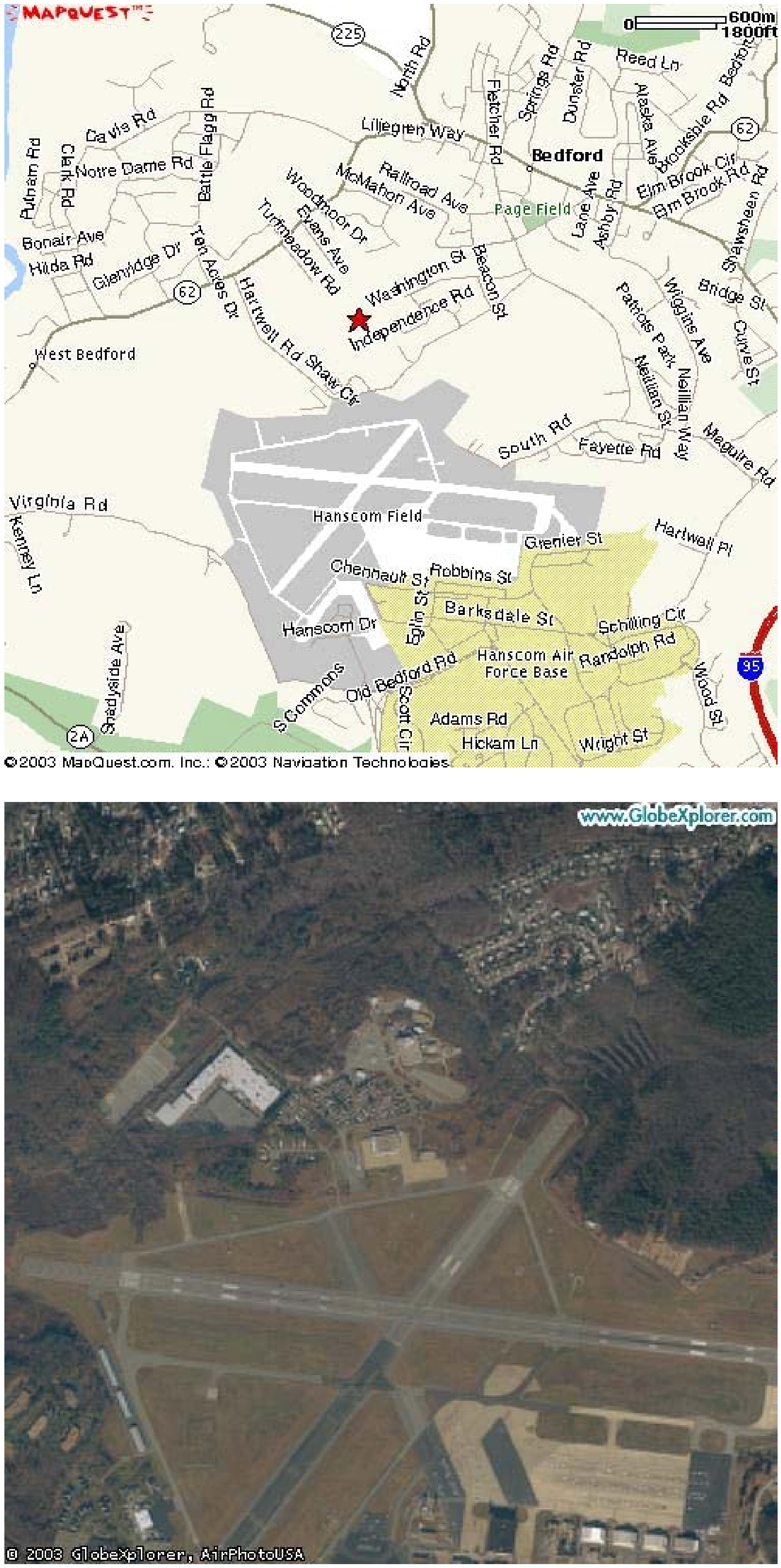
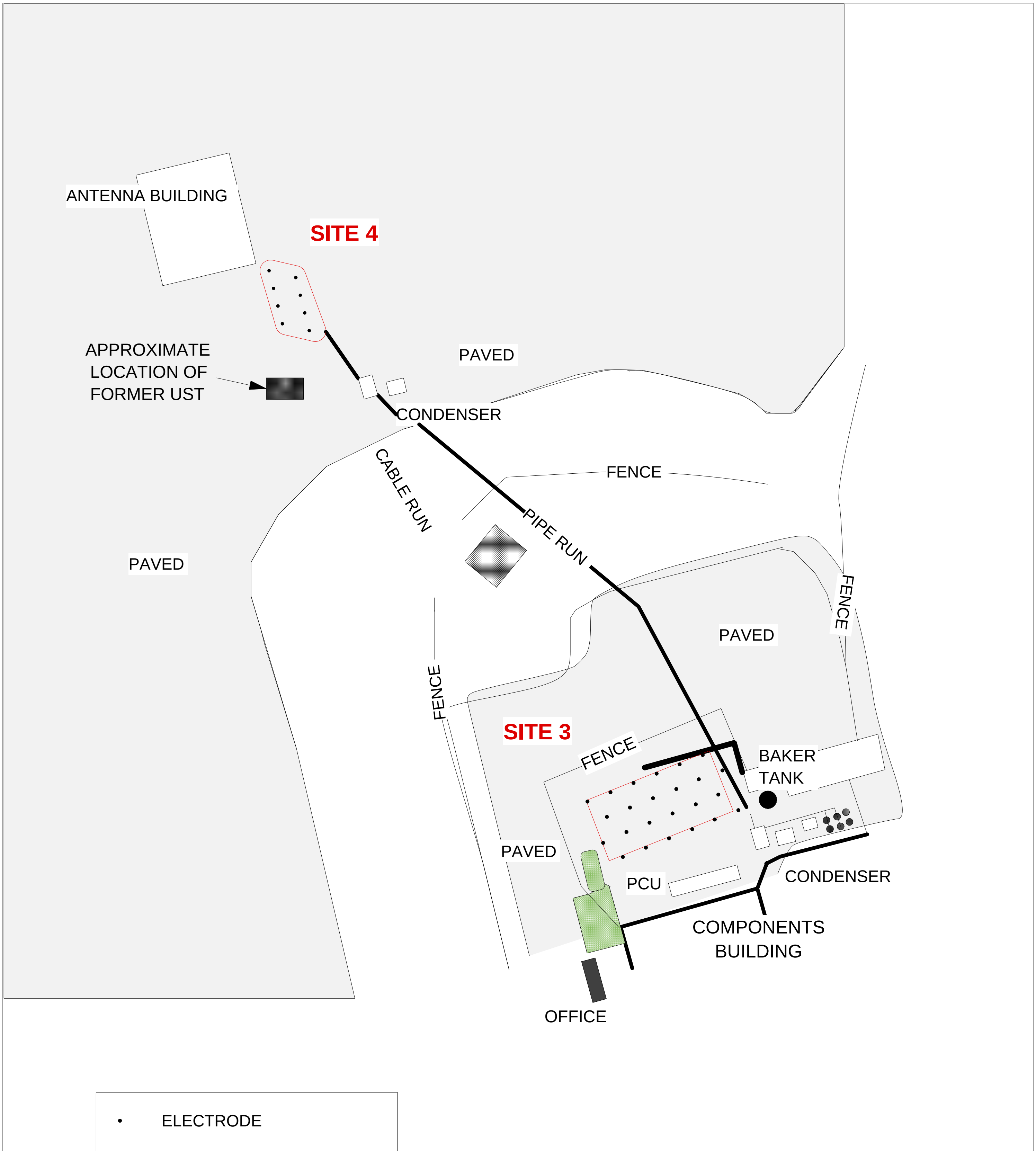


Figure 1: Bedford NWIRP Area Map and Aerial Photo



THERMAL REMEDIATION services inc.

BEDFORD NWIRP

PROJECT NO.	BED-02
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DRAWN BY	TDP
CHECKED BY	
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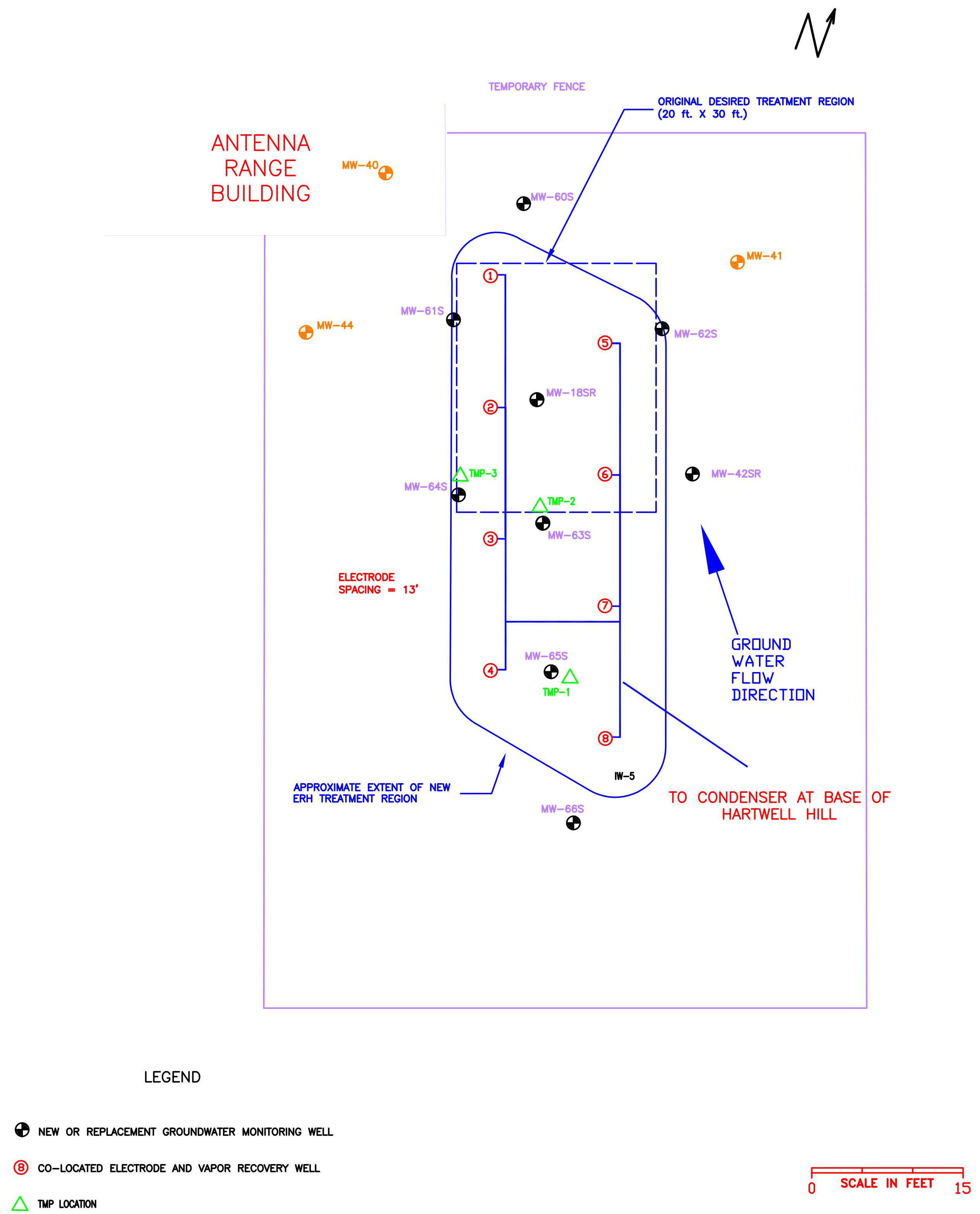
FIGURE #	2



NO.	DATE	BY	REVISIONS

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DRAWN BY:	GB
CHECKED BY:	TP
PROJECT MANAGER:	GS
DATE:	04/04/03
SCALE:	ON DWG
FIGURE NUMBER:	3
PROJECT NUMBER:	BED02

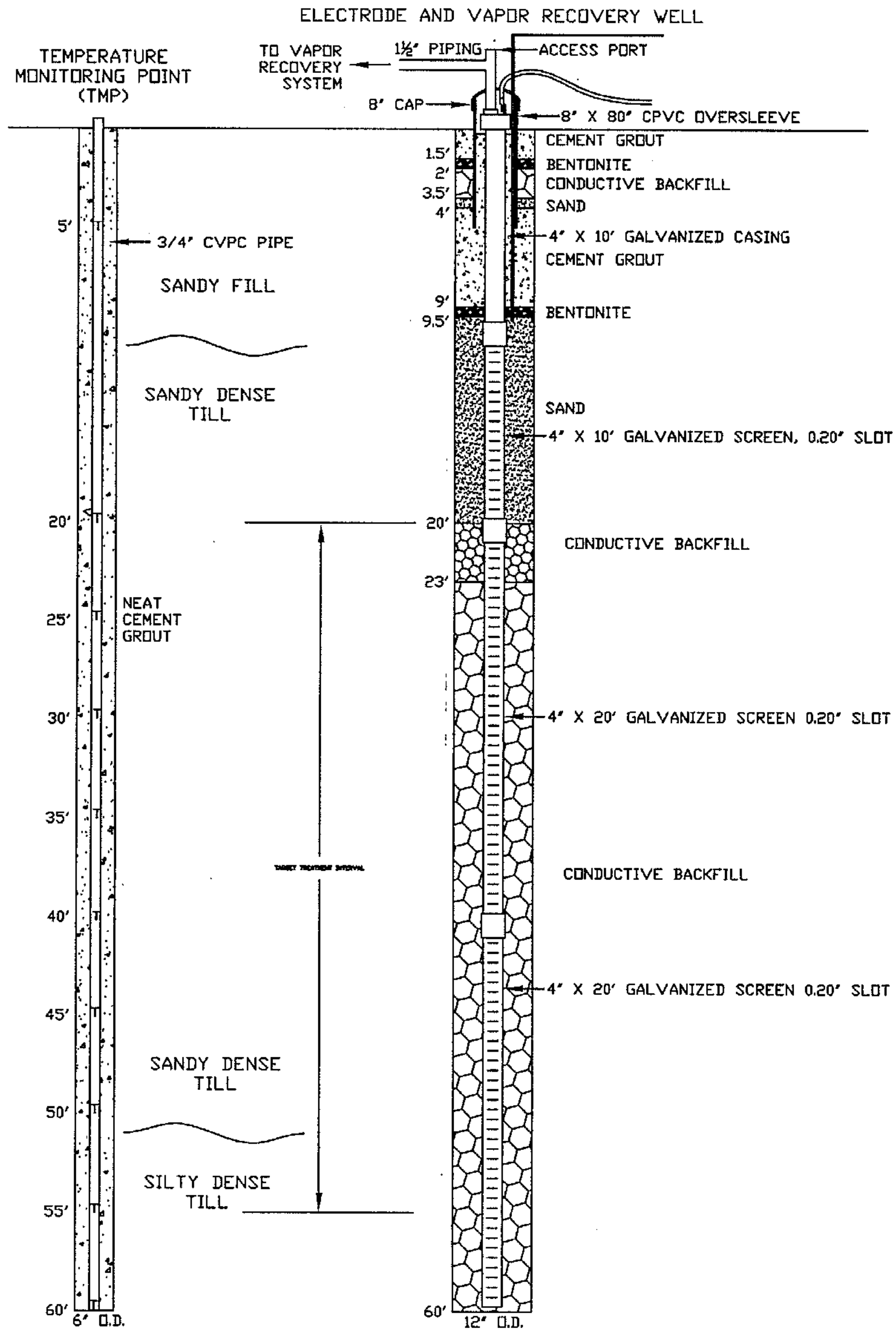
ENGINEER'S SEAL

SITE 4 PLOT PLAN

NWIRP BEDFORD, MA

THERMAL REMEDIATION services inc.

2325 HUDSON STREET
LONGVIEW, WA 98632



Source:
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FIGURE 2-1

NAVAL WEAPONS INDUSTRIAL RESERVE PLANT
BEDFORD, MASSACHUSETTS

ELECTRODE AND TMP CONSTRUCTION DETAILS

NOT TO SCALE

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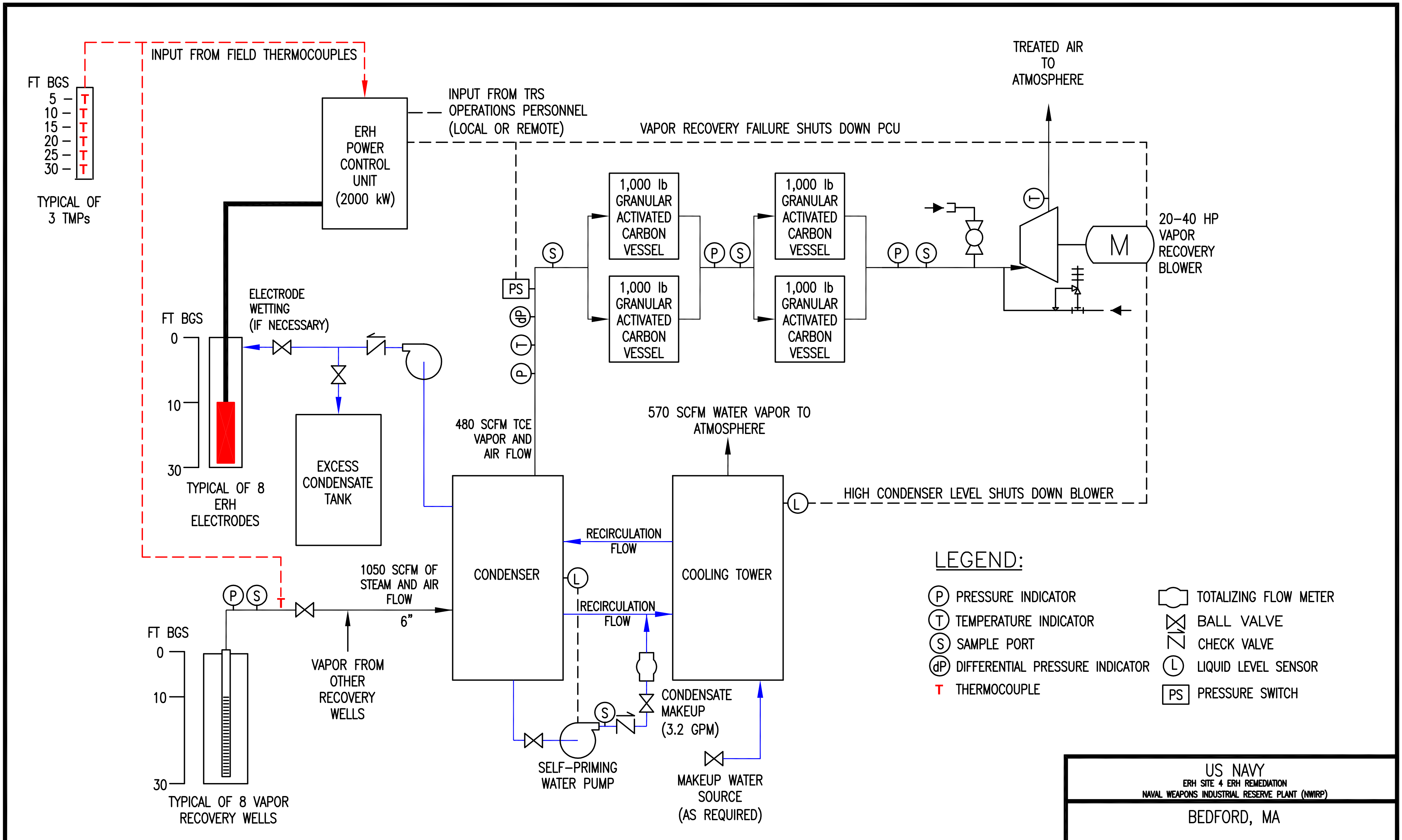

US NAVY
ERH SITE 4 ERH REMEDIATION
NAVAL WEAPONS INDUSTRIAL RESERVE PLANT (NWIRP)

BEDFORD, MA

THERMAL REMEDIATION services inc.

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Figure 5 Process Flow / Piping and Instrumentation Diagram

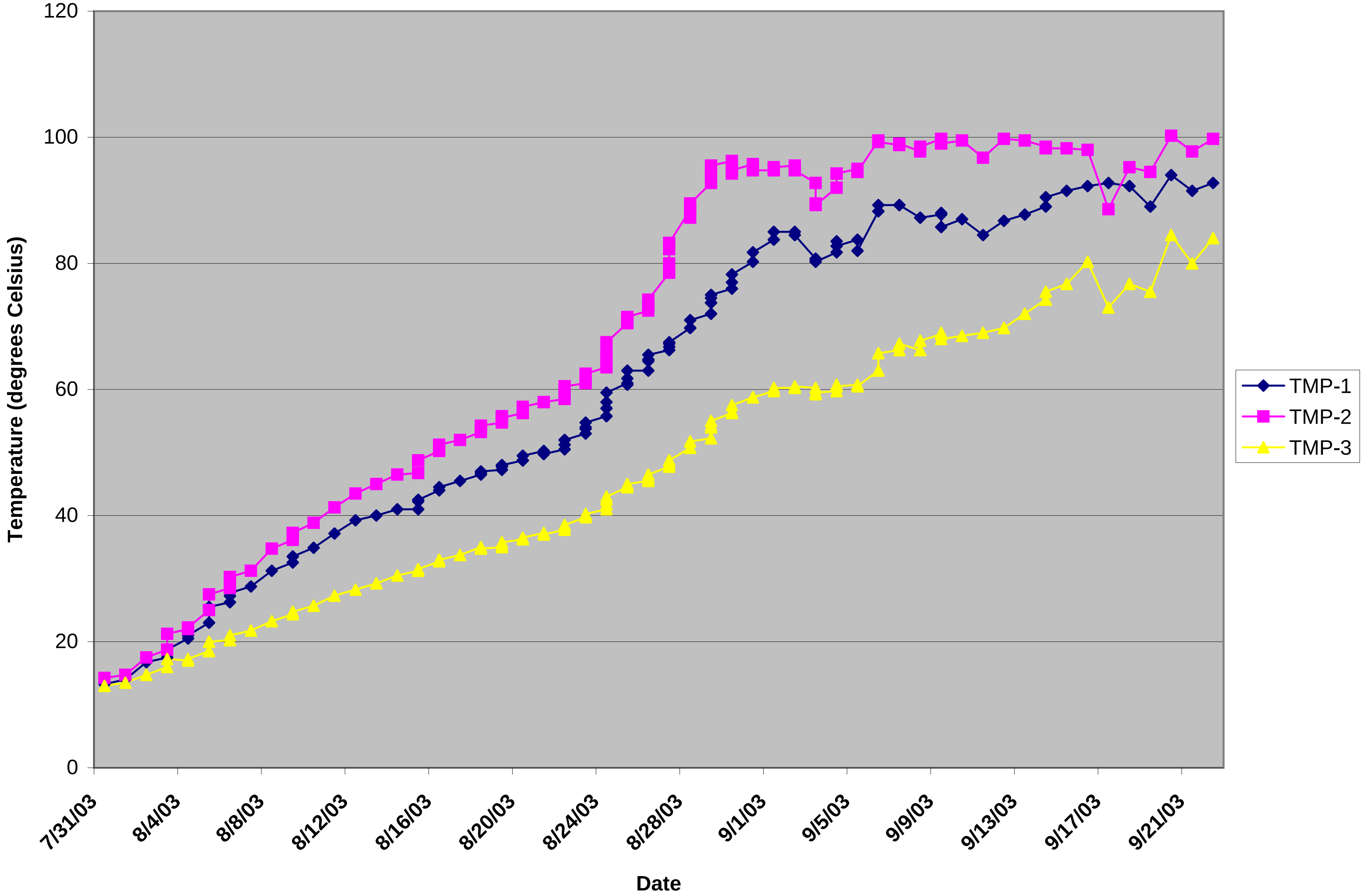


Figure 6: Site Temperature Results Per TMP Location

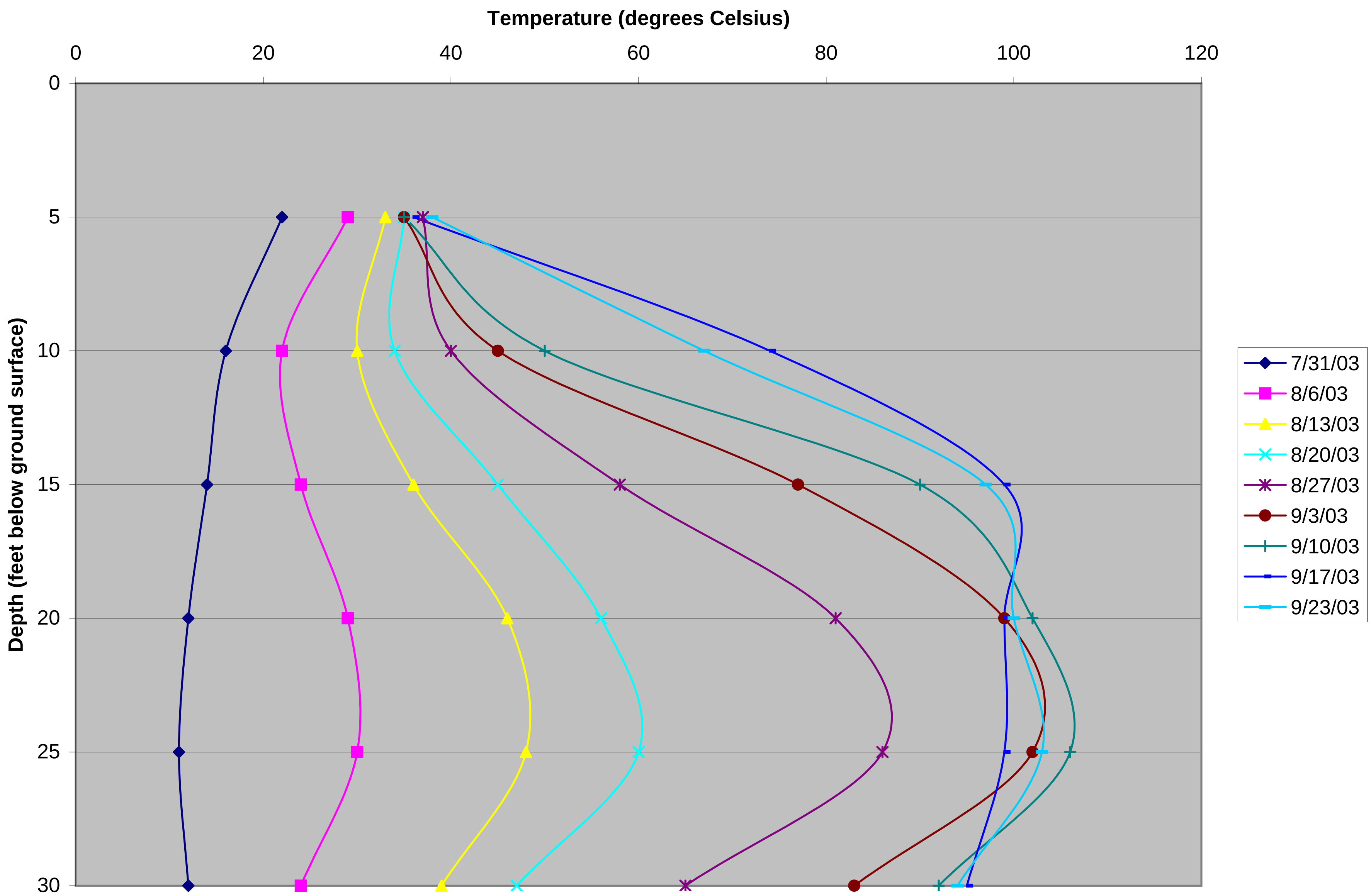


Figure 7: TMP-1 Average Temperatures Per Depth Interval During Operations

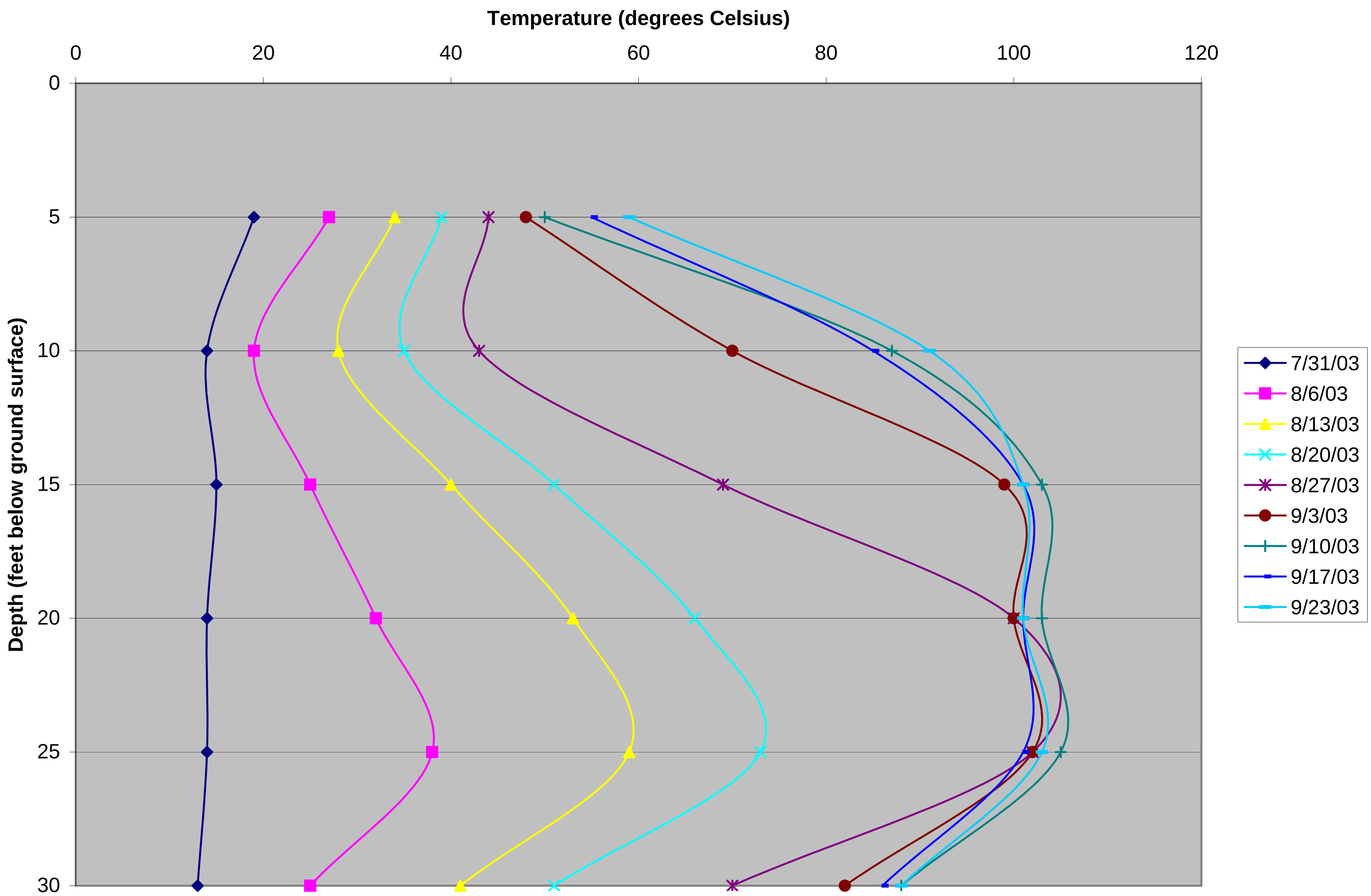


Figure 8: TMP-2 Average Temperatures Per Depth Interval During Operations

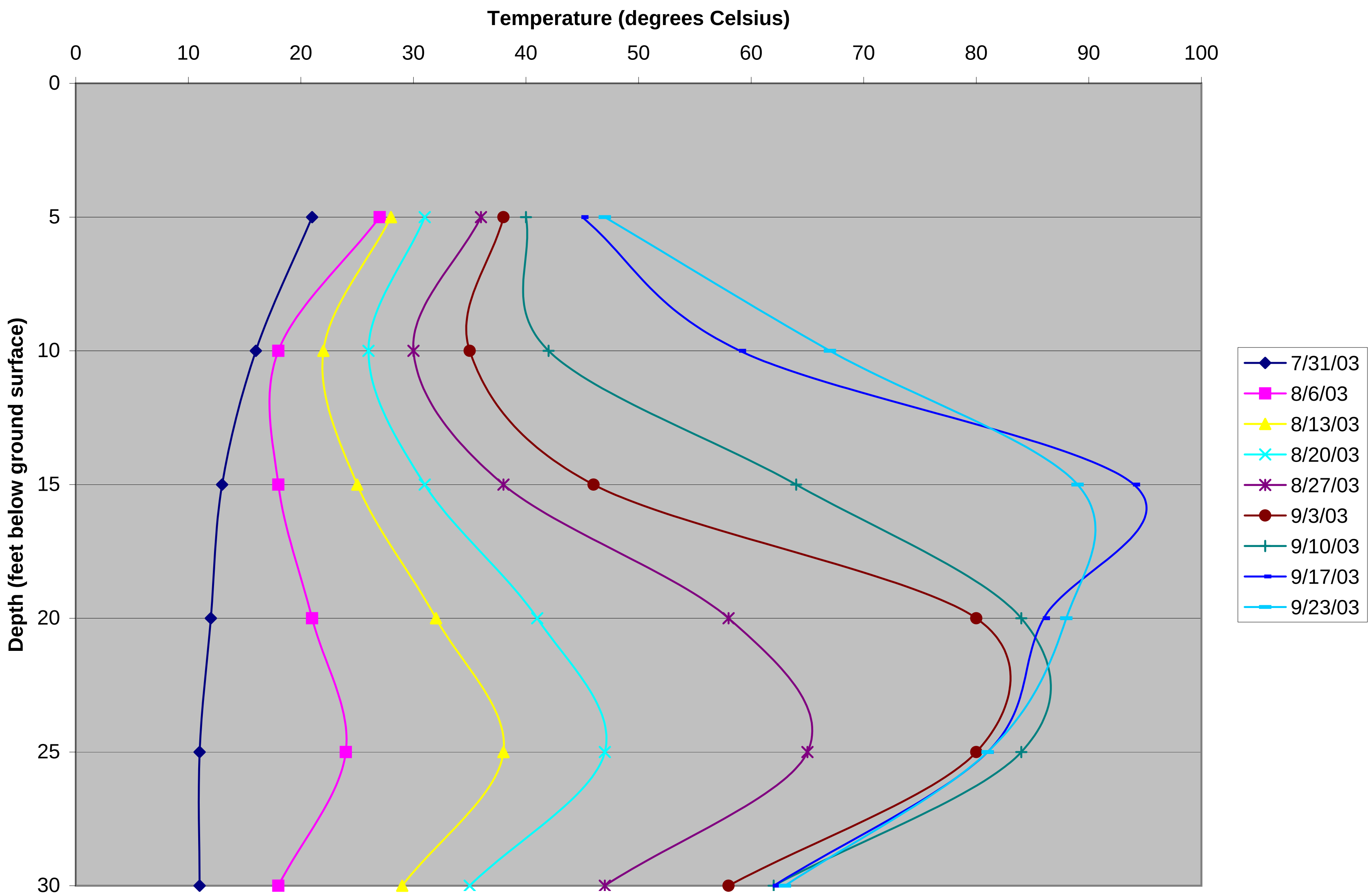
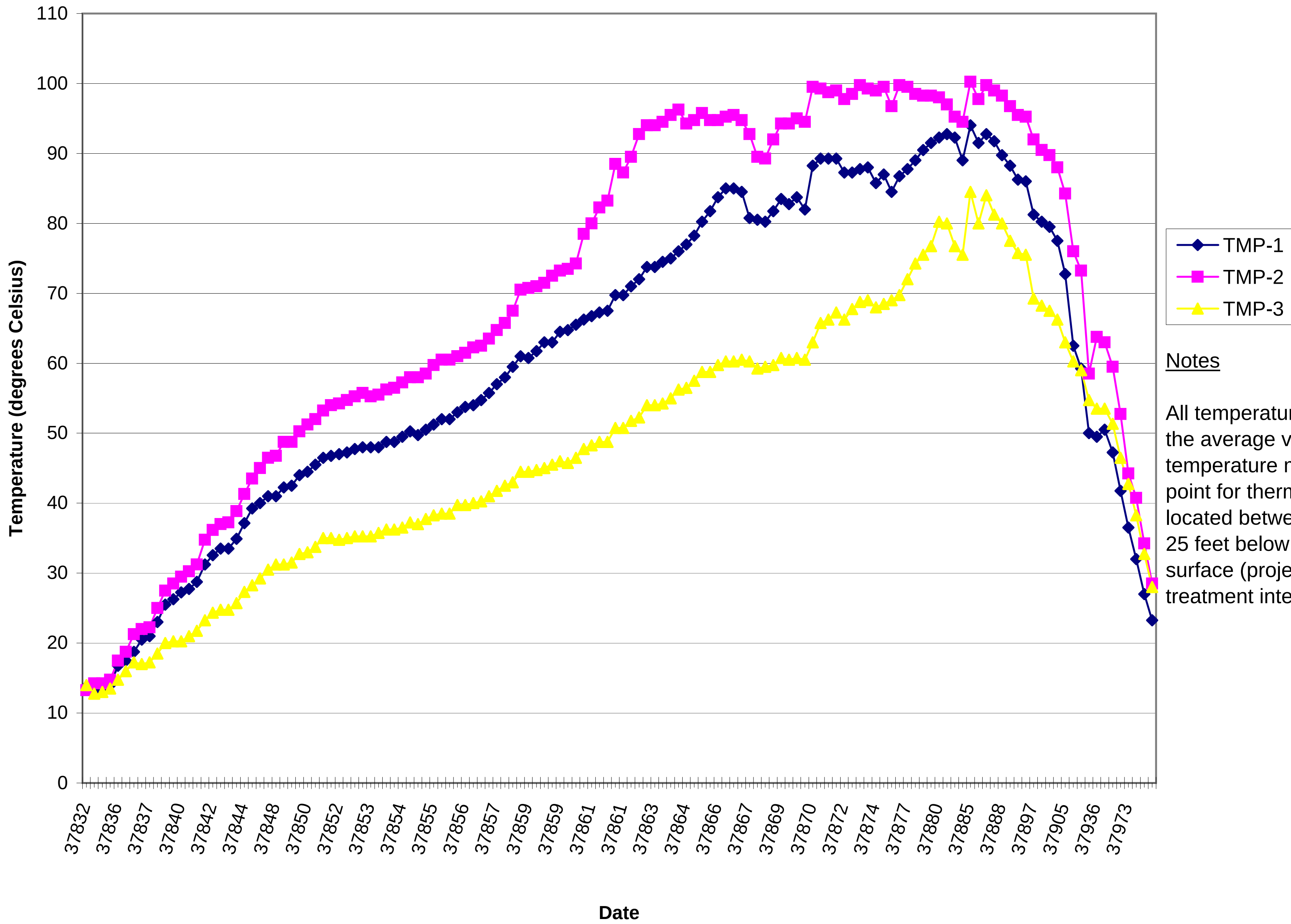


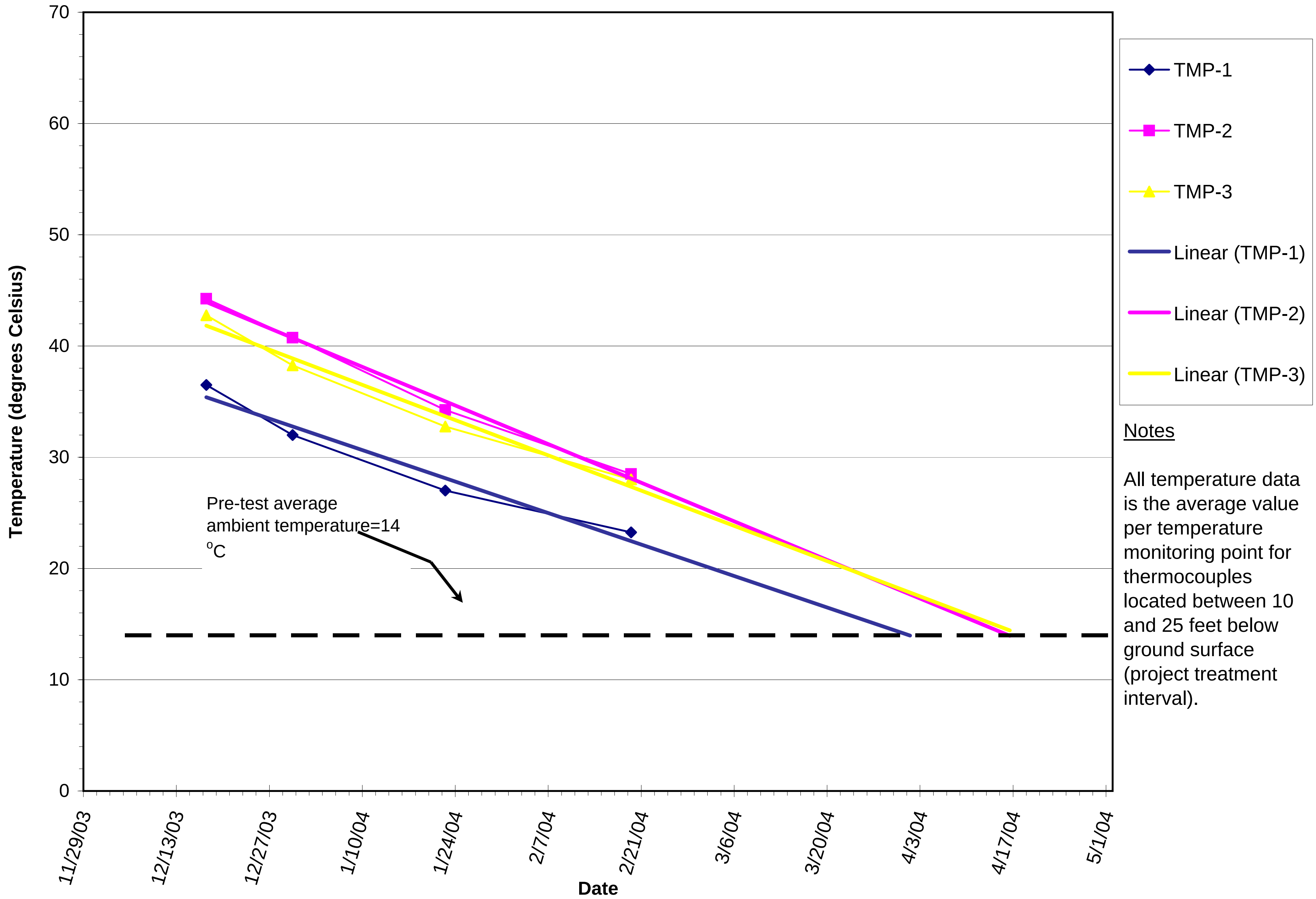
Figure 9: TMP-3 Average Temperatures Per Depth Interval During Operations



Notes

All temperature data is the average value per temperature monitoring point for thermocouples located between 10 and 25 feet below ground surface (project treatment interval).

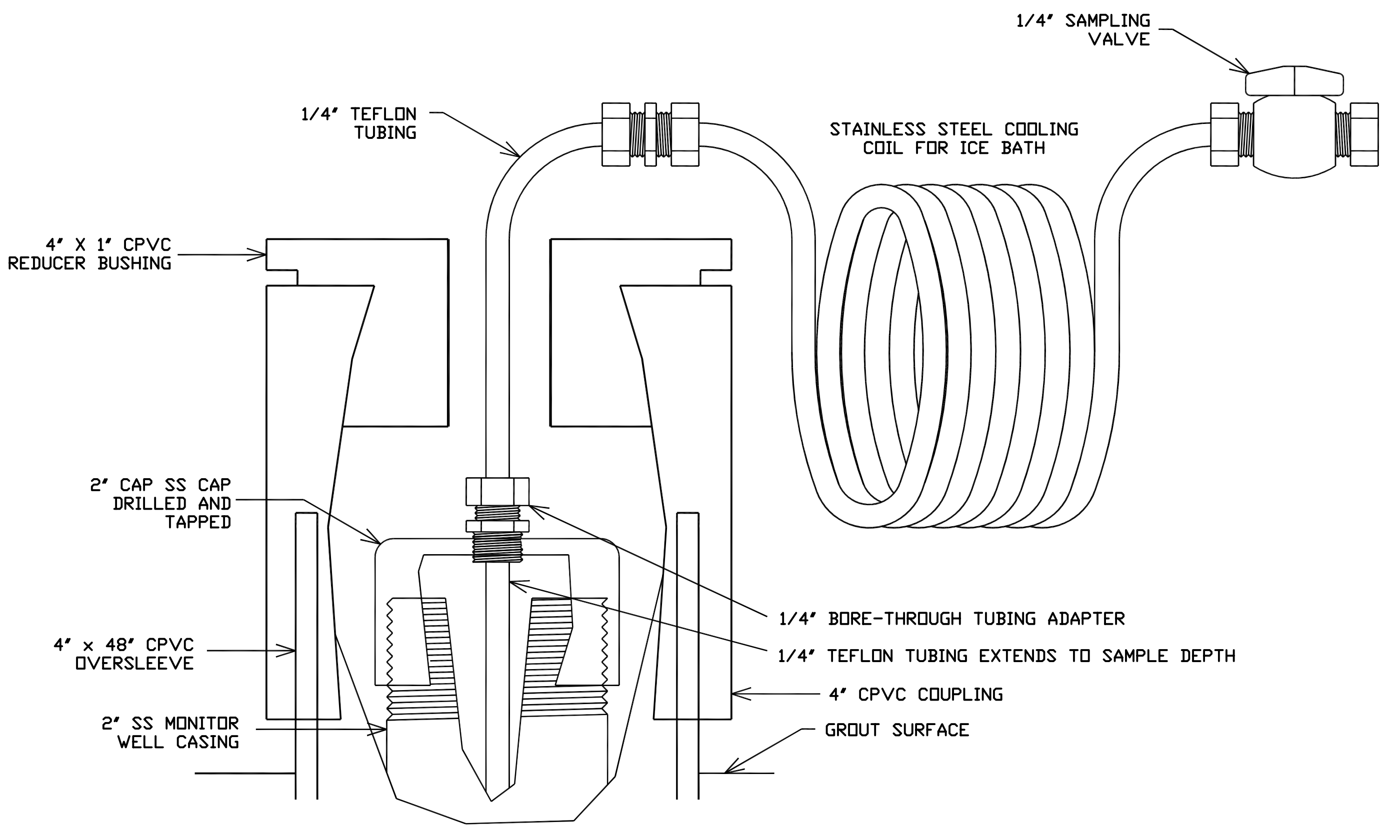
Figure 10: Site 4 Average Subsurface Temperature Decrease Per TMP Location



Notes

All temperature data is the average value per temperature monitoring point for thermocouples located between 10 and 25 feet below ground surface (project treatment interval).

Figure 11: Predicted Trend Line for Site 4 Subsurface Temperature Decrease



US NAVY
SITE 4 ERH REMEDIATION
NAVAL WEAPONS INDUSTRIAL RESERVE PLANT (NWIRP)

BEDFORD, MA

FIGURE 12: MONITORING WELLHEAD DETAIL
SITE 4 ERH REMEDIATION

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APPENDIX A

Analytical Results

Site 4 ERH Remediation

Site 4 Baseline Groundwater Analytical Results for May and June 2003

June 2003 Groundwater Sampling Event Dates (Site 4 Pre-Pilot Test)												
Compound	Treatment Area Location	Analytical Results										
		Treatment Area Locations and Sampling Dates										
		5/29/03	5/29/03D	5/29/03	5/30/03	5/30/03	6/2/03	6/2/03	6/2/03	6/15/03	6/30/03	6/30/03
	Units	MW-60S	MW-60S	MW-62S	MW-61S	MW-64S	MW-65S	MW-42SR	MW-63S	MW-18SR	IW-5	MW-66S
Previously Identified Primary Contaminants of Concern												
Benzene	µg/L	**250**	**250**	**59**	**76J**	**43**	**320**	**14**	**180**	**220**	**360**	**52**
Toluene	µg/L	**1800**	**2300**	**85**	**3800**	**920**	**5900**	**1.5J**	**4400**	**2200**	**1400**	**24**
Ethylbenzene	µg/L	**1600**	**1700**	**110**	**290**	**280**	**1500**	**34**	**1600**	**1200**	**800**	**210**
p/m-Xylene	µg/L	**3500**	**3800**	**410**	**7800**	**6700**	**6200**	**22**	**8700**	**3600**	**1800**	**130**
o-Xylene	µg/L	**1200**	**1800**	**150**	**4800**	**4200**	**2600**	**1.2J**	**4200**	**1500**	**600**	**43**
Total-Xylene	µg/L	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
Other Volatile Organic Compounds												
1,1,1-Trichloroethane (1,1,1-TCA)	µg/L	40U	40U	NA	100U	40U	100U	2.0U	100U	40U	20U	4U
1,1,2,2-Tetrachloroethane	µg/L	40U	40U	NA	100U	40U	100U	2.0U	100U	40U	20U	4U
1,1,2-Trichloroethane	µg/L	40U	40U	NA	100U	40U	100U	2.0U	100U	40U	20U	4U
1,1 Dichloroethane (1,1-DCA)	µg/L	40U	40U	NA	100U	40U	100U	2.0U	100U	40U	20U	4U
1,1-Dichloroethene	µg/L	40U	40U	NA	100U	40U	100U	2.0U	100U	40U	20U	4U
1,2-Dichloroethane	µg/L	40U	40U	NA	100U	40U	100U	2.0U	100U	40U	20U	4U
1,2-Dichloroethene (total)	µg/L	NA	NA	NA	NA	40U	100U	NA	100U	NA	20U	4U
1,2-Dichloropropane	µg/L	40U	40U	NA	100U	40U	100U	2.0U	100U	40U	20U	4U
2-Butanone (MEK)	µg/L	46	110	NA	110	150	100U	8.7	75J	42	39	4.8
2-Hexanone	µg/L	40U	40U	NA	100U	40U	100U	2.0U	100U	40U	20U	4U
4-Methyl-2-pentanone	µg/L	40U	40U	NA	100U	40U	100U	2.0U	100U	40U	20U	4U
Acetone	µg/L	110	210	51	190J	210	200J	29	220J	99J	100	18
Bromodichloromethane	µg/L	40U	40U	NA	100U	40U	100U	2.0U	100U	40U	20U	4U
Bromoform	µg/L	40U	40U	NA	100U	40U	100U	2.0U	100U	40U	20U	4U
Bromomethane	µg/L	100U	100U	NA	250U	100U	250U	5.0U	250U	100U	50U	10U
Carbon Disulfide	µg/L	40U	40U	NA	100U	40U	100U	2.0U	100U	40U	20U	4U
Carbon Tetrachloride	µg/L	40U	40U	NA	100U	40U	100U	2.0U	100U	40U	20U	4U
Chlorobenzene	µg/L	40U	40U	NA	100U	40U	100U	2.0U	100U	40U	20U	4U
Chloroethane	µg/L	40U	40U	NA	100U	40U	100U	2.0U	100U	40U	20U	4U
Chloroform	µg/L	40U	40U	26	100U	40U	100U	2.0U	100U	40U	20U	4.1
Chloromethane	µg/L	40U	40U	NA	100U	40U	100U	2.0U	100U	40U	20U	4U
Cis-1,2-Dichloroethene (cs-1,2-DCE	µg/L	40U	40U	NA	100U	40U	100U	2.0U	100U	40U	20U	4U
cis-1,3-Dichloropropene	µg/L	40U	40U	NA	100U	40U	100U	2.0U	100U	40U	20U	4U
Dibromochloromethane	µg/L	40U	40U	NA	100U	40U	100U	2.0U	100U	40U	20U	4U
Methylene Chloride	µg/L	100U	100U	NA	250U	100U	250U	5.0U	250U	100U	50U	10U
Methyl tert-butyl ether (MTBE)	µg/L	40U	40U	NA	100U	40U	100U	2.0U	100U	40U	20U	4U
Methyl isobutyl ketone (MIBK)	µg/L	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Naphthalene	µg/L	320	380	89	240	360	360	11	410	290	190	31
Styrene	µg/L	NA	40U	NA	100U	40U	100U	2.0U	100U	40U	20U	4U
Tetrachloroethene (PCE)	µg/L	NA	40U	NA	100U	40U	100U	2.0U	100U	40U	20U	4U
Trans-1,2-Dichloroethene	µg/L	40U	40U	NA	100U	40U	100U	2.0U	100U	40U	20U	4U
trans-1,3-Dichloropropene	µg/L	40U	40U	NA	100U	40U	100U	2.0U	100U	40U	20U	4U
Trichloroethene (TCE)	µg/L	40U	40U	NA	100U	40U	100U	1.2J	100U	29J	16J	5.4
Vinyl Chloride	µg/L	40U	40U	NA	100U	24J	100U	2.0U	100U	40U	20U	4U

Notes

Laboratory Qualifiers
U = Not Detected; Detection Limit Listed
J = Quantitation Approximate
ND = Not Detected; Detection Limit Unknown
NA = Not Available
E= Estimtated value, exceeds the upper limit of calibration
D= Duplicate

Other
Analytical Data Table developed from laboratory reports and samples collected by TTFW
TTFW = Tetra Tech Foster Wheeler
VOC= volatile organic compound
µg/L = micrograms per lites
NE = Not established
Location outside of treatment volume

Site 4 Mid-Heating Groundwater Analytical Results for September 2003

September 2003 Mid-Heating Groundwater Sampling Event (Site 4 Operations)													
VOC Constituent Per Treatment Area Monitoring Well Location													
Compound	Units	MW-18SR			MW-63S			MW-65S			MW-65S (D)		
		May/June Baseline	9/9/03 Results	Remediation Goal (μg/L)	May/June Baseline	9/9/03 Results	Remediation Goal (μg/L)	May/June Base	9/9/03 Results	Remediation Goal (μg/L)	May/June Base	9/9/03 Results	Remediation Goal (μg/L)
Previously Identified Primary Contaminants of Concern													
Benzene	μg/L	**220**	**2.0U**	50	**180**	**10U**	50	**320**	**18J**	50	**320**	**14J**	50
Toluene	μg/L	**2,200**	**6.8**	NE	**4,400**	**14**	NE	**5,900**	**600**	NE	**5,900**	**520**	NE
Ethylbenzene	μg/L	**1,200**	**3.1**	NE	**1,600**	**6.0J**	NE	**1,500**	**420**	NE	**1,500**	**370**	NE
p/m-Xylene	μg/L	**3,600**	**18**	NE	**8,700**	**31**	NE	**6,200**	**1800**	NE	**6,200**	**1600**	NE
o-Xylene	μg/L	**1,500**	**2.7**	NE	**4,200**	**7.0J**	NE	**2,600**	**910**	NE	**2,600**	**780**	NE
Total-Xylene	μg/L	**NA**	**NA**	NE	**NA**	**NA**	NE	**NA**	**NA**	NE	**NA**	**NA**	NE
Other Volatile Organic Compounds													
Chloromethane	μg/L	40U	2.0U	NE	100U	10U	NE	100U	20U	NE	100U	20U	NE
Cis-1,2-Dichloroethene (cs-1,2-DCE)	μg/L	40U	NA	NE	100U	NA	NE	100U	NA	NE	100U	NA	NE
Trans-1,2-Dichloroethene	μg/L	40U	NA	NE	100U	NA	NE	100U	NA	NE	100U	NA	NE
1,2-Dichloroethene (total)	μg/L	NA	5.0U	NE	100U	10U	NE	100U	20U	NE	100U	20U	NE
1,1 Dichloroethane (1,1-DCA)	μg/L	40U	2.0U	NE	100U	10U	NE	100U	20U	NE	100U	20U	NE
1,1,1-Trichloroethane (1,1,1-TCA)	μg/L	40U	2.0U	NE	100U	10U	NE	100U	20U	NE	100U	20U	NE
Trichloroethene (TCE)	μg/L	29J	2.0U	NE	100U	10U	NE	100U	20U	NE	100U	20U	NE
Tetrachloroethene (PCE)	μg/L	40U	2.0U	NE	100U	10U	NE	100U	20U	NE	100U	20U	NE
Vinyl Chloride	μg/L	40U	2.0U	NE	100U	10U	NE	100U	20U	NE	100U	20U	NE
Bromomethane	μg/L	100U	5.0U	NE	250U	25U	NE	250U	50U	NE	250U	50U	NE
Chloroethane	μg/L	40U	2.0U	NE	100U	10U	NE	100U	20U	NE	100U	20U	NE
Acetone	μg/L	**99J**	**220E**	NE	220J	2300E	NE	200J	840	NE	200J	710	NE
1,1-Dichloroethene	μg/L	40U	2.0U	NE	100U	10U	NE	100U	20U	NE	100U	20U	NE
Carbon Disulfide	μg/L	40U	1.0J	NE	100U	**13**	NE	100U	20U	NE	100U	20U	NE
Methylene Chloride	μg/L	100U	5.0U	NE	250U	25U	NE	250U	50U	NE	250U	50U	NE
Methyl tert-butyl ether (MTBE)	μg/L	40U	2.0U	NE	100U	10U	NE	100U	20U	NE	100U	20U	NE
2-Butanone (MEK)	μg/L	**42**	**12**	NE	**75J**	**250**	NE	100U	**110**	NE	100U	100	NE
Chloroform	μg/L	40U	2.0U	NE	100U	10U	NE	100U	20U	NE	100U	20U	NE
Carbon Tetrachloride	μg/L	40U	2.0U	NE	100U	10U	NE	100U	20U	NE	100U	20U	NE
1,2-Dichloroethane	μg/L	40U	2.0U	NE	100U	10U	NE	100U	20U	NE	100U	20U	NE
1,2-Dichloropropane	μg/L	40U	2.0U	NE	100U	10U	NE	100U	20U	NE	100U	20U	NE
Bromodichloromethane	μg/L	40U	2.0U	NE	100U	10U	NE	100U	20U	NE	100U	20U	NE
Methyl isobutyl ketone (MIBK)	μg/L	NA	5.0U	NE	NA	25U	NE	NA	50U	NE	NA	50U	NE
cis-1,3-Dichloropropene	μg/L	40U	2.0U	NE	100U	10U	NE	100U	20U	NE	100U	20U	NE
trans-1,3-Dichloropropene	μg/L	40U	2.0U	NE	100U	10U	NE	100U	20U	NE	100U	20U	NE
1,1,2-Trichloroethane	μg/L	40U	2.0U	NE	100U	10U	NE	100U	20U	NE	100U	20U	NE
2-Hexanone	μg/L	40U	5.0U	NE	100U	25U	NE	100U	50U	NE	100U	50U	NE
Dibromochloromethane	μg/L	40U	2.0U	NE	100U	10U	NE	100U	20U	NE	100U	20U	NE
Chlorobenzene	μg/L	40U	2.0U	NE	100U	10U	NE	100U	20U	NE	100U	20U	NE
Styrene	μg/L	40U	5.0U	NE	100U	25U	NE	100U	50U	NE	100U	50U	NE
Bromoform	μg/L	40U	2.0U	NE	100U	10U	NE	100U	20U	NE	100U	20U	NE
1,1,2,2-Tetrachloroethane	μg/L	40U	2.0U	NE	100U	10U	NE	100U	20U	NE	100U	20U	NE
Naphthalene	μg/L	290	2.5J	NE	410	11J	NE	360	790	NE	360	670	NE

Notes

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Other
Analytical Data Table developed from laboratory reports and samples collected by TTFW
TTFW = Tetra Tech Foster Wheeler
VOC= volatile organic compound
μg/L = micrograms per lites
NE = Not established
Location outside of treatment volume

Site 4 Groundwater Analytical Results for September 2003

September 2003 Groundwater Sampling Event (Site 4 Operations)										
VOC Constituent Per Treatment Area Monitoring Well Location										
Compound		MW-60S			MW-61S			MW-64S		
	Units	May/June Baseline	9/29/03 Results	Remediation Goal (µg/L)	May/June Baseline	9/30/03 Results	Remediation Goal (µg/L)	May/June Base	9/30/03 Results	Remediation Goal (µg/L)
Previously Identified Primary Contaminants of Concern										
Benzene	µg/L	250	**140**	50	76J	**14J**	50	43	**32J**	50
Toluene	µg/L	1,800	**670**	NE	3,800	**830**	NE	920	**1000**	NE
Ethylbenzene	µg/L	1,600	**2100**	NE	290	**650**	NE	280	**1000**	NE
p/m-Xylene	µg/L	3,500	**4600**	NE	7,800	**4700E**	NE	6,700	**4900**	NE
o-Xylene	µg/L	1,200	**1100**	NE	4,800	**2600E**	NE	4,200	**2600**	NE
Total-Xylene	µg/L	NA	**NA**	NE	NA	**NA**	NE	NA	**NA**	NE
Other Volatile Organic Compounds										
Chloromethane	µg/L	40U	40U	NE	100U	20U	NE	40U	40U	NE
Cis-1,2-Dichloroethene (cs-1,2-DCE	µg/L	40U	NA	NE	100U	NA	NE	40U	NA	NE
Trans-1,2-Dichloroethene	µg/L	40U	NA	NE	100U	NA	NE	40U	NA	NE
1,2-Dichloroethene (total)	µg/L	NA	40U	NE	NA	20U	NE	40U	40U	NE
1,1 Dichloroethane (1,1-DCA)	µg/L	40U	40U	NE	100U	20U	NE	40U	40U	NE
1,1,1-Trichloroethane (1,1,1-TCA)	µg/L	40U	40U	NE	100U	20U	NE	40U	40U	NE
Trichloroethene (TCE)	µg/L	40U	40U	NE	100U	20U	NE	40U	40U	NE
Tetrachloroethene (PCE)	µg/L	NA	40U	NE	100U	20U	NE	40U	40U	NE
Vinyl Chloride	µg/L	40U	40U	NE	100U	20U	NE	24J	40U	NE
Bromomethane	µg/L	100U	40U	NE	250U	20U	NE	100U	40U	NE
Chloroethane	µg/L	40U	40U	NE	100U	20U	NE	40U	40U	NE
Acetone	µg/L	110	73J	NE	190J	320	NE	210	2400	NE
1,1-Dichloroethene	µg/L	40U	40U	NE	100U	20U	NE	40U	40U	NE
Carbon Disulfide	µg/L	40U	40U	NE	100U	20U	NE	40U	40U	NE
Methylene Chloride	µg/L	100U	100U	NE	250U	50U	NE	100U	100U	NE
Methyl tert-butyl ether (MTBE)	µg/L	40U	40U	NE	100U	20U	NE	40U	40U	NE
2-Butanone (MEK)	µg/L	46	26J	NE	110	97	NE	150	460	NE
Chloroform	µg/L	40U	40U	NE	100U	20U	NE	40U	40U	NE
Carbon Tetrachloride	µg/L	40U	40U	NE	100U	20U	NE	40U	40U	NE
1,2-Dichloroethane	µg/L	40U	40U	NE	100U	20U	NE	40U	40U	NE
1,2-Dichloropropane	µg/L	40U	40U	NE	100U	20U	NE	40U	40U	NE
Bromodichloromethane	µg/L	40U	40U	NE	100U	20U	NE	40U	40U	NE
Methyl isobutyl ketone (MIBK)	µg/L	NA	40U	NE	NA	20U	NE	NA	40U	NE
cis-1,3-Dichloropropene	µg/L	40U	40U	NE	100U	20U	NE	40U	40U	NE
trans-1,3-Dichloropropene	µg/L	40U	40U	NE	100U	20U	NE	40U	40U	NE
1,1,2-Trichloroethane	µg/L	40U	40U	NE	100U	20U	NE	40U	40U	NE
2-Hexanone	µg/L	40U	40U	NE	100U	20U	NE	40U	22J	NE
Dibromochloromethane	µg/L	40U	40U	NE	100U	20U	NE	40U	40U	NE
Chlorobenzene	µg/L	40U	40U	NE	100U	20U	NE	40U	40U	NE
Styrene	µg/L	NA	40U	NE	100U	20U	NE	40U	40U	NE
Bromoform	µg/L	40U	40U	NE	100U	20U	NE	40U	40U	NE
1,1,2,2-Tetrachloroethane	µg/L	40U	40U	NE	100U	20U	NE	40U	40U	NE
Naphthalene	µg/L	320	600	NE	240	170	NE	360	1700	NE

Notes

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Analytical Data Table developed from laboratory reports and samples collected by TTFW
TTFW = Tetra Tech Foster Wheeler
VOC= volatile organic compound
µg/L = micrograms per lites
NE = Not established
Location outside of treatment volume

Site 4 Groundwater Analytical Results for September 2003

September 2003 Groundwater Sampling Event Dates (Site 4 Operations)										
VOC Constituent Per Treatment Area Monitoring Well Location										
Compound	Units	MW-18SR			MW-42SR			MW-65S		
		May/June Baseline	9/30/03 Results	Remediation Goal (μg/L)	May/June Baseline	9/30/03 Results	Remediation Goal (μg/L)	May/June Baseline	9/30/03 Results	Remediation Goal (μg/L)
Previously Identified Primary Contaminants of Concern										
Benzene	μg/L	**220**	**3.3J**	50	**14**	**20**	50	**320**	**6.2J**	50
Toluene	μg/L	**2,200**	**24**	NE	**1.5J**	**7.4J**	NE	**5,900**	**81**	NE
Ethylbenzene	μg/L	**1,200**	**15**	NE	**34**	**65**	NE	**1,500**	**78**	NE
p/m-Xylene	μg/L	**3,600**	**64**	NE	**22**	**71**	NE	**6,200**	**330**	NE
o-Xylene	μg/L	**1,500**	**40**	NE	**1.2J**	**18**	NE	**2,600**	**120**	NE
Total-Xylene	μg/L	**NA**	**NA**	NE	**NA**	**NA**	NE	**NA**	**NA**	NE
Other Volatile Organic Compounds										
Chloromethane	μg/L	40U	4.0U	NE	2.0U	10U	NE	100U	10U	NE
Cis-1,2-Dichloroethene (cs-1,2-DCE	μg/L	40U	NA	NE	2.0U	NA	NE	100U	NA	NE
Trans-1,2-Dichloroethene	μg/L	40U	NA	NE	2.0U	NA	NE	100U	NA	NE
1,2-Dichloroethene (total)	μg/L	NA	4.0U	NE	NA	10U	NE	NA	10U	NE
1,1 Dichloroethane (1,1-DCA)	μg/L	40U	4.0U	NE	2.0U	10U	NE	100U	10U	NE
1,1,1-Trichloroethane (1,1,1-TCA)	μg/L	40U	4.0U	NE	2.0U	10U	NE	100U	10U	NE
Trichloroethene (TCE)	μg/L	29J	4.0U	NE	1.2J	10U	NE	100U	6.9J	NE
Tetrachloroethene (PCE)	μg/L	40U	4.0U	NE	2.0U	10U	NE	100U	10U	NE
Vinyl Chloride	μg/L	40U	4.0U	NE	2.0U	10U	NE	100U	10U	NE
Bromomethane	μg/L	100U	4.0U	NE	5.0U	10U	NE	250U	10U	NE
Chloroethane	μg/L	40U	4.0U	NE	2.0U	10U	NE	100U	10U	NE
Acetone	μg/L	99J	690E	NE	29	39	NE	200J	370	NE
1,1-Dichloroethene	μg/L	40U	4.0U	NE	2.0U	10U	NE	100U	10U	NE
Carbon Disulfide	μg/L	40U	4.0U	NE	2.0U	10U	NE	100U	10U	NE
Methylene Chloride	μg/L	100U	10U	NE	5.0U	25U	NE	250U	10U	NE
Methyl tert-butyl ether (MTBE)	μg/L	40U	4.0U	NE	2.0U	10U	NE	100U	10U	NE
2-Butanone (MEK)	μg/L	42	91	NE	9	11	NE	100U	42	NE
Chloroform	μg/L	40U	4.0U	NE	2.0U	10U	NE	100U	10U	NE
Carbon Tetrachloride	μg/L	40U	4.0U	NE	2.0U	10U	NE	100U	10U	NE
1,2-Dichloroethane	μg/L	40U	4.0U	NE	2.0U	10U	NE	100U	10U	NE
1,2-Dichloropropane	μg/L	40U	4.0U	NE	2.0U	10U	NE	100U	10U	NE
Bromodichloromethane	μg/L	40U	4.0U	NE	2.0U	10U	NE	100U	10U	NE
Methyl isobutyl ketone (MIBK)	μg/L	NA	4.0U	NE	NA	10U	NE	NA	10U	NE
cis-1,3-Dichloropropene	μg/L	40U	4.0U	NE	2.0U	10U	NE	100U	10U	NE
trans-1,3-Dichloropropene	μg/L	40U	4.0U	NE	2.0U	10U	NE	100U	10U	NE
1,1,2-Trichloroethane	μg/L	40U	4.0U	NE	2.0U	10U	NE	100U	10U	NE
2-Hexanone	μg/L	40U	2.7J	NE	2.0U	10U	NE	100U	25U	NE
Dibromochloromethane	μg/L	40U	4.0U	NE	2.0U	10U	NE	100U	10U	NE
Chlorobenzene	μg/L	40U	4.0U	NE	2.0U	10U	NE	100U	10U	NE
Styrene	μg/L	40U	4.0U	NE	2.0U	10U	NE	100U	10U	NE
Bromoform	μg/L	40U	4.0U	NE	2.0U	10U	NE	100U	10U	NE
1,1,2,2-Tetrachloroethane	μg/L	40U	4.0U	NE	2.0U	10U	NE	100U	10U	NE
Naphthalene	μg/L	290	40	NE	11	28	NE	360	90	NE

Notes

Laboratory Qualifiers

U = Not Detected; Detection Limit Listed

J = Quantitation Approximate

ND = Not Detected; Detection Limit Unknown

NA = Not Available

E= Estimtated value, exceeds the upper limit of calibration

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Other

Analytical Data Table developed from laboratory reports and samples collected by TTFW

TTFW = Tetra Tech Foster Wheeler

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NE = Not established

Location outside of treatment volume

Site 4 Groundwater Analytical Results for October 2003

October 2003 Groundwater Sampling Event Results (Site 4 Operations)													
VOC Constituent Per Treatment Area Monitoring Well Location													
Compound		MW-66S			MW-66S (D)			MW-63S			MW-62S		
	Units	May/June Baseline	10/1/03 Results	Remediation Goal (µg/L)	May/June Baseline	10/1/03 Results	Remediation Goal (µg/L)	May/June Base	10/1/03 Results	Remediation Goal (µg/L)	May/June Base	10/2/03 Results	Remediation Goal (µg/L)
Previously Identified Primary Contaminants of Concern													
Benzene	µg/L	**52**	**32**	50	**52**	**32**	50	**180**	**20U**	50	**59**	**66J**	50
Toluene	µg/L	**24**	**91**	NE	**24**	**86**	NE	**4,400**	**27**	NE	**85**	**230**	NE
Ethylbenzene	µg/L	**210**	**26**	NE	**210**	**26**	NE	**1,600**	**25**	NE	**110**	**790**	NE
p/m-Xylene	µg/L	**130**	**260**	NE	**130**	**250**	NE	**8,700**	**62**	NE	**410**	**2000**	NE
o-Xylene	µg/L	**43**	**93**	NE	**43**	**90**	NE	**4,200**	**24**	NE	**150**	**710**	NE
Total-Xylene	µg/L	**NA**	**NA**	NE	**NA**	**NA**	NE	**NA**	**NA**	NE	**NA**	**NA**	NE
Other Volatile Organic Compounds													
Chloromethane	µg/L	4U	10U	NE	4U	10U	NE	100U	20U	NE	NA	100U	NE
Cis-1,2-Dichloroethene (cs-1,2-DC	µg/L	4U	NA	NE	4U	NA	NE	100U	NA	NE	NA	NA	NE
Trans-1,2-Dichloroethene	µg/L	4U	NA	NE	4U	NA	NE	100U	NA	NE	NA	NA	NE
1,2-Dichloroethene (total)	µg/L	4U	10U	NE	4U	10U	NE	100U	20U	NE	NA	100U	NE
1,1 Dichloroethane (1,1-DCA)	µg/L	4U	10U	NE	4U	10U	NE	100U	20U	NE	NA	100U	NE
1,1,1-Trichloroethane (1,1,1-TCA)	µg/L	4U	10U	NE	4U	10U	NE	100U	20U	NE	NA	100U	NE
Trichloroethene (TCE)	µg/L	**5.4**	**6.7J**	NE	**5.4**	**6.3J**	NE	100U	20U	NE	NA	100U	NE
Tetrachloroethene (PCE)	µg/L	4U	10U	NE	4U	10U	NE	100U	20U	NE	NA	100U	NE
Vinyl Chloride	µg/L	4U	10U	NE	4U	10U	NE	100U	20U	NE	NA	100U	NE
Bromomethane	µg/L	10U	10U	NE	10U	10U	NE	250U	20U	NE	NA	100U	NE
Chloroethane	µg/L	4U	10U	NE	4U	10U	NE	100U	20U	NE	NA	100U	NE
Acetone	µg/L	**18**	**25**	NE	**18**	**23J**	NE	**220J**	**620**	NE	**51**	**310**	NE
1,1-Dichloroethene	µg/L	4U	10U	NE	4U	10U	NE	100U	20U	NE	NA	100U	NE
Carbon Disulfide	µg/L	4U	10U	NE	4U	10U	NE	100U	20U	NE	NA	100U	NE
Methylene Chloride	µg/L	10U	10U	NE	10U	10U	NE	250U	20U	NE	NA	100U	NE
Methyl tert-butyl ether (MTBE)	µg/L	4U	10U	NE	4U	10U	NE	100U	20U	NE	NA	100U	NE
2-Butanone (MEK)	µg/L	**5**	**9.8J**	NE	**5**	**9.3J**	NE	**75J**	**92**	NE	NA	**63J**	NE
Chloroform	µg/L	**4**	10U	NE	**4**	10U	NE	100U	20U	NE	**26**	100U	NE
Carbon Tetrachloride	µg/L	4U	10U	NE	4U	10U	NE	100U	20U	NE	NA	100U	NE
1,2-Dichloroethane	µg/L	4U	10U	NE	4U	10U	NE	100U	20U	NE	NA	100U	NE
1,2-Dichloropropane	µg/L	4U	10U	NE	4U	10U	NE	100U	20U	NE	NA	100U	NE
Bromodichloromethane	µg/L	4U	10U	NE	4U	10U	NE	100U	20U	NE	NA	100U	NE
Methyl isobutyl ketone (MIBK)	µg/L	NA	**7.5J**	NE	NA	**7.2J**	NE	NA	20U	NE	NA	100U	NE
cis-1,3-Dichloropropene	µg/L	4U	10U	NE	4U	10U	NE	100U	20U	NE	NA	100U	NE
trans-1,3-Dichloropropene	µg/L	4U	10U	NE	4U	10U	NE	100U	20U	NE	NA	100U	NE
1,1,2-Trichloroethane	µg/L	4U	10U	NE	4U	10U	NE	100U	20U	NE	NA	100U	NE
2-Hexanone	µg/L	4U	25U	NE	4U	25U	NE	100U	50U	NE	NA	250U	NE
Dibromochloromethane	µg/L	4U	10U	NE	4U	10U	NE	100U	20U	NE	NA	100U	NE
Chlorobenzene	µg/L	4U	10U	NE	4U	10U	NE	100U	20U	NE	NA	100U	NE
Styrene	µg/L	4U	10U	NE	4U	10U	NE	100U	20U	NE	NA	100U	NE
Bromoform	µg/L	4U	10U	NE	4U	10U	NE	100U	20U	NE	NA	100U	NE
1,1,2,2-Tetrachloroethane	µg/L	4U	10U	NE	4U	10U	NE	100U	20U	NE	NA	100U	NE
Naphthalene	µg/L	**31**	**8.7J**	NE	**31**	**8.6J**	NE	**410**	**21**	NE	**89**	**340**	NE

Notes

Laboratory Qualifiers
U = Not Detected; Detection Limit Listed
J = Quantitation Approximate
ND = Not Detected; Detection Limit Unknown
NA = Not Available
E= Estimtated value, exceeds the upper limit of calibration
D= Duplicate

Other
Analytical Data Table developed from laboratory reports and samples collected by TTFW
TTFW = Tetra Tech Foster Wheeler
VOC= volatile organic compound
µg/L = micrograms per lites
NE = Not established
Location outside of treatment volume

Site 4 Groundwater Analytical Results for April 2004

April 2004 Groundwater Sampling Event (Site 4 Operations)													
VOC Constituent Per Treatment Area Monitoring Well Location													
Compound	Units	MW-60S			MW-61S			MW-64S			MW-66S		
		May/June Baseline	4/14/04 Results	Remediation Goal (µg/L)	May/June Baseline	4/13/04 Results	Remediation Goal (µg/L)	May/June Base	4/14/04 Results	Remediation Goal (µg/L)	May/June Base	4/13/04 Results	Remediation Goal (µg/L)
Previously Identified Primary Contaminants of Concern													
Benzene	µg/L	250	**7.6**	50	76J	**2.0U**	50	43	**4.4**	50	52	**91**	50
Toluene	µg/L	1,800	**1.3J**	NE	3,800	**2.0U**	NE	920	**13**	NE	24	**46**	NE
Ethylbenzene	µg/L	1,600	**97**	NE	290	**2.0U**	NE	280	**130**	NE	210	**290**	NE
p/m-Xylene	µg/L	3,500	**26**	NE	7,800	**34**	NE	6,700	**1100E**	NE	130	**190**	NE
o-Xylene	µg/L	1,200	**6.5**	NE	4,800	**16**	NE	4,200	**310E**	NE	43	**88**	NE
Total-Xylene	µg/L	NA	**NA**	NE	NA	**NA**	NE	NA	**NA**	NE	NA	**NA**	NE
Other Volatile Organic Compounds													
Chloromethane	µg/L	40U	2.0U	NE	100U	2.0U	NE	40U	2.0U	NE	4U	2.0U	NE
Cis-1,2-Dichloroethene (cs-1,2-DC	µg/L	40U	NA	NE	100U	NA	NE	40U	NA	NE	4U	NA	NE
Trans-1,2-Dichloroethene	µg/L	40U	NA	NE	100U	NA	NE	40U	NA	NE	4U	NA	NE
1,2-Dichloroethene (total)	µg/L	NA	4.5	NE	NA	2.0U	NE	40U	2.0U	NE	4U	2.7	NE
1,1 Dichloroethane (1,1-DCA)	µg/L	40U	2.0U	*NE*	100U	2.0U	*NE*	40U	2.0U	*NE*	4U	2.0U	*NE*
1,1,1-Trichloroethane (1,1,1-TCA)	µg/L	40U	2.0U	NE	100U	2.0U	NE	40U	2.0U	NE	4U	2.0U	NE
Trichloroethene (TCE)	µg/L	40U	1.4J	NE	100U	2.0U	NE	40U	2.0U	NE	5.4	3.5	NE
Tetrachloroethene (PCE)	µg/L	NA	2.0U	NE	100U	2.0U	NE	40U	2.0U	NE	4U	2.0U	NE
Vinyl Chloride	µg/L	40U	2.0U	NE	100U	2.0U	NE	24J	2.0U	NE	4U	2.0U	NE
Bromomethane	µg/L	100U	2.0U	NE	250U	2.0U	NE	100U	2.0U	NE	10U	2.0U	NE
Chloroethane	µg/L	40U	2.0U	NE	100U	2.0U	NE	40U	2.0U	NE	4U	1.6J	NE
Acetone	µg/L	110	4.1J	NE	190J	4.0J	NE	210	13	NE	18	5.0U	NE
1,1-Dichloroethene	µg/L	40U	2.0U	NE	100U	2.0U	NE	40U	2.0U	NE	4U	2.0U	NE
Carbon Disulfide	µg/L	40U	2.0U	NE	100U	2.0U	NE	40U	2.0U	NE	4U	2.0U	NE
Methylene Chloride	µg/L	100U	5.0U	NE	250U	5.0U	NE	100U	5.0U	NE	10U	5.0U	NE
Methyl tert-butyl ether (MTBE)	µg/L	40U	2.0U	NE	100U	2.0U	NE	40U	2.0U	NE	4U	2.0U	NE
2-Butanone (MEK)	µg/L	46	1.8J	*NE*	110	2.0J	*NE*	150	7.5	*NE*	5	14	*NE*
Chloroform	µg/L	40U	2.0U	NE	100U	2.0U	NE	40U	2.0U	NE	4	2.0U	NE
Carbon Tetrachloride	µg/L	40U	2.0U	NE	100U	2.0U	NE	40U	2.0U	NE	4U	2.0U	NE
1,2-Dichloroethane	µg/L	40U	2.0U	NE	100U	2.0U	NE	40U	2.0U	NE	4U	2.0U	NE
1,2-Dichloropropane	µg/L	40U	2.0U	NE	100U	2.0U	NE	40U	2.0U	NE	4U	2.0U	NE
Bromodichloromethane	µg/L	40U	2.0U	NE	100U	2.0U	NE	40U	2.0U	NE	4U	2.0U	NE
Methyl isobutyl ketone (MIBK)	µg/L	NA	2.0U	NE	NA	1.0J	NE	NA	1.7J	NE	NA	2.0U	NE
cis-1,3-Dichloropropene	µg/L	40U	2.0U	NE	100U	2.0U	NE	40U	2.0U	NE	4U	2.0U	NE
trans-1,3-Dichloropropene	µg/L	40U	2.0U	NE	100U	2.0U	NE	40U	2.0U	NE	4U	2.0U	NE
1,1,2-Trichloroethane	µg/L	40U	2.0U	NE	100U	2.0U	NE	40U	2.0U	NE	4U	2.0U	NE
2-Hexanone	µg/L	40U	1.6J	NE	100U	4	NE	40U	4.2	NE	4U	2.0U	NE
Dibromochloromethane	µg/L	40U	2.0U	NE	100U	2.0U	NE	40U	2.0U	NE	4U	2.0U	NE
Chlorobenzene	µg/L	40U	2.0U	NE	100U	2.0U	NE	40U	2.0U	NE	4U	2.0U	NE
Styrene	µg/L	NA	2.0U	NE	100U	2.0U	NE	40U	2.0U	NE	4U	2.0U	NE
Bromoform	µg/L	40U	2.0U	NE	100U	2.0U	NE	40U	2.0U	NE	4U	2.0U	NE
1,1,2,2-Tetrachloroethane	µg/L	40U	2.0U	NE	100U	2.0U	NE	40U	2.0U	NE	4U	2.0U	NE
Naphthalene	µg/L	320	52	NE	240	1.2J	NE	360	670E	NE	31	40	NE

Notes

Laboratory Qualifiers

U = Not Detected; Detection Limit Listed

J = Quantitation Approximate

ND = Not Detected; Detection Limit Unknown

NA = Not Available

E= Estimtated value, exceeds the upper limit of calibration

D= Duplicate

Other

Analytical Data Table developed from laboratory reports and samples collected by TTFW

TTFW = Tetra Tech Foster Wheeler

VOC= volatile organic compound

µg/L = micrograms per lites

NE = Not established

Location outside of treatment volume

Site 4 Groundwater Analytical Results for April 2004

April 2004 Groundwater Sampling Event Dates (Site 4 Operations)													
VOC Constituent Per Treatment Area Monitoring Well Location													
Compound	Units	MW-18SR			MW-42SR			MW-65S			MW-62S		
		May/June Baseline	4/14/04 Results	Remediation Goal (µg/L)	May/June Baseline	4/13/04 Results	Remediation Goal (µg/L)	May/June Baseline	4/14/04 Results	Remediation Goal (µg/L)	May/June Baseline	4/13/04 Results	Remediation Goal (µg/L)
Previously Identified Primary Contaminants of Concern													
Benzene	µg/L	**220**	**41**	50	**14**	**2.2**	50	**320**	**40**	50	**59**	**3.4**	50
Toluene	µg/L	**2,200**	**13**	NE	**1.5J**	**2.0U**	NE	**5,900**	**310E**	NE	**85**	**17**	NE
Ethylbenzene	µg/L	**1,200**	**650E**	NE	**34**	**15**	NE	**1,500**	**330E**	NE	**110**	**12**	NE
p/m-Xylene	µg/L	**3,600**	**840E**	NE	**22**	**14**	NE	**6,200**	**740E**	NE	**410**	**47**	NE
o-Xylene	µg/L	**1,500**	**50**	NE	**1.2J**	**2.0U**	NE	**2,600**	**460E**	NE	**150**	**20**	NE
Total-Xylene	µg/L	**NA**	**NA**	NE	**NA**	**NA**	NE	**NA**	**NA**	NE	**NA**	**NA**	NE
Other Volatile Organic Compounds													
Chloromethane	µg/L	40U	2.0U	NE	2.0U	2.0U	NE	100U	2.0U	NE	NA	2.0U	NE
Cis-1,2-Dichloroethene (cs-1,2-DC	µg/L	40U	NA	NE	2.0U	NA	NE	100U	NA	NE	NA	NA	NE
Trans-1,2-Dichloroethene	µg/L	40U	NA	NE	2.0U	NA	NE	100U	NA	NE	NA	NA	NE
1,2-Dichloroethene (total)	µg/L	NA	16	NE	NA	2.0U	NE	NA	4.4	NE	NA	2.0U	NE
1,1 Dichloroethane (1,1-DCA)	µg/L	40U	1.4J	*NE*	2.0U	2.0U	*NE*	100U	2.0U	*NE*	NA	2.0U	*NE*
1,1,1-Trichloroethane (1,1,1-TCA)	µg/L	40U	2.0U	NE	2.0U	2.0U	NE	100U	2.0U	NE	NA	2.0U	NE
Trichloroethene (TCE)	µg/L	29J	1.9J	NE	1.2J	2.0U	NE	100U	5.6	NE	NA	2.0U	NE
Tetrachloroethene (PCE)	µg/L	40U	2.0U	NE	2.0U	2.0U	NE	100U	2.0U	NE	NA	2.0U	NE
Vinyl Chloride	µg/L	40U	2.0U	NE	2.0U	2.0U	NE	100U	2.0U	NE	NA	2.0U	NE
Bromomethane	µg/L	100U	2.0U	NE	5.0U	2.0U	NE	250U	2.0U	NE	NA	2.0U	NE
Chloroethane	µg/L	40U	2.0U	NE	2.0U	2.0U	NE	100U	2.0U	NE	NA	2.0U	NE
Acetone	µg/L	99J	11	NE	29	8.5	NE	200J	16	NE	51	2.7J	NE
1,1-Dichloroethene	µg/L	40U	1.6J	NE	2.0U	2.0U	NE	100U	2.0U	NE	NA	2.0U	NE
Carbon Disulfide	µg/L	40U	2.0U	NE	2.0U	2.0U	NE	100U	2.0U	NE	NA	2.0U	NE
Methylene Chloride	µg/L	100U	5.0U	NE	5.0U	5.0U	NE	250U	5.0U	NE	NA	5.0U	NE
Methyl tert-butyl ether (MTBE)	µg/L	40U	2.0U	NE	2.0U	2.0U	NE	100U	2.0U	NE	NA	2.0U	NE
2-Butanone (MEK)	µg/L	42	4.4	*NE*	9	2.5	*NE*	100U	6.6	*NE*	NA	2.0	*NE*
Chloroform	µg/L	40U	2.0U	NE	2.0U	2.0U	NE	100U	2.0U	NE	26	2.0U	NE
Carbon Tetrachloride	µg/L	40U	2.0U	NE	2.0U	2.0U	NE	100U	2.0U	NE	NA	2.0U	NE
1,2-Dichloroethane	µg/L	40U	2.0U	NE	2.0U	2.0U	NE	100U	2.0U	NE	NA	2.0U	NE
1,2-Dichloropropane	µg/L	40U	2.0U	NE	2.0U	2.0U	NE	100U	2.0U	NE	NA	2.0U	NE
Bromodichloromethane	µg/L	40U	2.0U	NE	2.0U	2.0U	NE	100U	2.0U	NE	NA	2.0U	NE
Methyl isobutyl ketone (MIBK)	µg/L	NA	3.7	NE	NA	2.0U	NE	NA	2.0U	NE	NA	2.0U	NE
cis-1,3-Dichloropropene	µg/L	40U	2.0U	NE	2.0U	2.0U	NE	100U	2.0U	NE	NA	2.0U	NE
trans-1,3-Dichloropropene	µg/L	40U	2.0U	NE	2.0U	2.0U	NE	100U	2.0U	NE	NA	2.0U	NE
1,1,2-Trichloroethane	µg/L	40U	2.0U	NE	2.0U	2.0U	NE	100U	2.0U	NE	NA	2.0U	NE
2-Hexanone	µg/L	40U	1.3J	NE	2.0U	2.0U	NE	100U	1.1J	NE	NA	2.0U	NE
Dibromochloromethane	µg/L	40U	2.0U	NE	2.0U	2.0U	NE	100U	2.0U	NE	NA	2.0U	NE
Chlorobenzene	µg/L	40U	2.0U	NE	2.0U	2.0U	NE	100U	2.0U	NE	NA	2.0U	NE
Styrene	µg/L	40U	3.2	NE	2.0U	2.0U	NE	100U	2.0U	NE	NA	2.0U	NE
Bromoform	µg/L	40U	2.0U	NE	2.0U	2.0U	NE	100U	2.0U	NE	NA	2.0U	NE
1,1,2,2-Tetrachloroethane	µg/L	40U	2.0U	NE	2.0U	2.0U	NE	100U	2.0U	NE	NA	2.0U	NE
Naphthalene	µg/L	290	480E	E	11	5.1	NE	360	190	NE	89	15	NE

Notes

Laboratory Qualifiers

U = Not Detected; Detection Limit Listed

J = Quantitation Approximate

ND = Not Detected; Detection Limit Unknown

NA = Not Available

E= Estimtated value, exceeds the upper limit of calibration

D= Duplicate

Other

Analytical Data Table developed from laboratory reports and samples collected by TTFW

TTFW = Tetra Tech Foster Wheeler

VOC= volatile organic compound

µg/L = micrograms per lites

NE = Not established

Location outside of treatment volume

Site 4 Groundwater Analytical Results for April 2004

April 2004 Groundwater Sampling Event Dates (Site 4 Operations)							
VOC Constituent Per Treatment Area Monitoring Well Location							
Compound	Units	MW-62S (D)			MW-63S		
		May/June Baseline	4/13/04 Results	Remediation Goal (µg/L)	May/June Baseline	4/14/04 Results	Remediation Goal (µg/L)
Previously Identified Primary Contaminants of Concern							
Benzene	µg/L	59	**3.5**	50	180	**26**	50
Toluene	µg/L	85	**17**	NE	4,400	**27**	NE
Ethylbenzene	µg/L	110	**12**	NE	1,600	**510E**	NE
p/m-Xylene	µg/L	410	**48**	NE	8,700	**1200E**	NE
o-Xylene	µg/L	150	**19**	NE	4,200	**350E**	NE
Total-Xylene	µg/L	NA	**NA**	NE	NA	**NA**	NE
Other Volatile Organic Compounds							
Chloromethane	µg/L	NA	2.0U	NE	100U	2.0U	NE
Cis-1,2-Dichloroethene (cs-1,2-DC	µg/L	NA	NA	NE	100U	NA	NE
Trans-1,2-Dichloroethene	µg/L	NA	NA	NE	100U	NA	NE
1,2-Dichloroethene (total)	µg/L	NA	2.0U	NE	100U	6.8	NE
1,1 Dichloroethane (1,1-DCA)	µg/L	NA	2.0U	*NE*	100U	2.0U	*NE*
1,1,1-Trichloroethane (1,1,1-TCA)	µg/L	NA	2.0U	NE	100U	2.0U	NE
Trichloroethene (TCE)	µg/L	NA	2.0U	NE	100U	1.2J	NE
Tetrachloroethene (PCE)	µg/L	NA	2.0U	NE	100U	2.0U	NE
Vinyl Chloride	µg/L	NA	2.0U	NE	100U	2.0U	NE
Bromomethane	µg/L	NA	2.0U	NE	250U	2.0U	NE
Chloroethane	µg/L	NA	2.0U	NE	100U	2.0U	NE
Acetone	µg/L	51	2.6J	NE	220J	24	NE
1,1-Dichloroethene	µg/L	NA	2.0U	NE	100U	2.0U	NE
Carbon Disulfide	µg/L	NA	2.0U	NE	100U	2.0U	NE
Methylene Chloride	µg/L	NA	5.0U	NE	250U	5.0U	NE
Methyl tert-butyl ether (MTBE)	µg/L	NA	2.0U	NE	100U	2.0U	NE
2-Butanone (MEK)	µg/L	NA	2.6	*NE*	75J	11	*NE*
Chloroform	µg/L	26	2.0U	NE	100U	2.0U	NE
Carbon Tetrachloride	µg/L	NA	2.0U	NE	100U	2.0U	NE
1,2-Dichloroethane	µg/L	NA	2.0U	NE	100U	2.0U	NE
1,2-Dichloropropane	µg/L	NA	2.0U	NE	100U	2.0U	NE
Bromodichloromethane	µg/L	NA	2.0U	NE	100U	2.0U	NE
Methyl isobutyl ketone (MIBK)	µg/L	NA	2.0U	NE	NA	2.8	NE
cis-1,3-Dichloropropene	µg/L	NA	2.0U	NE	100U	2.0U	NE
trans-1,3-Dichloropropene	µg/L	NA	2.0U	NE	100U	2.0U	NE
1,1,2-Trichloroethane	µg/L	NA	2.0U	NE	100U	2.0U	NE
2-Hexanone	µg/L	NA	2.0U	NE	100U	2.2	NE
Dibromochloromethane	µg/L	NA	2.0U	NE	100U	2.0U	NE
Chlorobenzene	µg/L	NA	2.0U	NE	100U	2.0U	NE
Styrene	µg/L	NA	2.0U	NE	100U	2.0U	NE
Bromoform	µg/L	NA	2.0U	NE	100U	2.0U	NE
1,1,2,2-Tetrachloroethane	µg/L	NA	2.0U	NE	100U	2.0U	NE
Naphthalene	µg/L	89	15	NE	410	680E	NE

Notes

Laboratory Qualifiers

U = Not Detected; Detection Limit Listed
J = Quantitation Approximate
ND = Not Detected; Detection Limit Unknown
NA = Not Available
E= Estimtated value, exceeds the upper limit of calibration
D= Duplicate

Other

Analytical Data Table developed from laboratory reports and samples collected by TTFW
TTFW = Tetra Tech Foster Wheeler
VOC= volatile organic compound
µg/L = micrograms per lites
NE = Not established
Location outside of treatment volume

Sites 4 and 3 Influent Vapor Analytical Results
Bedford NWIRP Site
Bedford, Massachusetts

Vapor Sample Results (Site 4 ERH Remediation Operations)					
Sample Collection Analysis Date	Primary VOCs (ppmv)				
	Benzene	Toluene	Ethyl benzene	Xylene (total)	PCE
7/31/03	0.025U	0.025U	0.025U	0.2	4.6
8/7/03	0.017U	0.088	0.048	0.229	1.20
8/14/03	0.16U	1.2	0.89	4.07	15
8/22/03	0.8U	1.40	1.40	5.8	17.00
8/28/03	0.31U	0.21	1.2	5.6	16
9/6/03	0.08U	0.21	0.17	0.85	2.00
9/11/03	0.25U	0.47	0.44	2.13	4
9/11/2003, Duplicate	0	0.45	0.42	2.00	3.8

Date Collected	7/31/03			8/7/03			8/14/03			8/22/03			8/28/03			9/6/03			9/11/03			9/11/2003, Duplicate		
Analyte	ppbv	ppmv	Qual.	ppbv	ppmv	Qual.	ppbv	ppmv	Qual.	ppbv	ppmv	Qual.	ppbv	ppmv	Qual.	ppbv	ppmv	Qual.	ppbv	ppmv	Qual.	ppbv	ppmv	Qual.
1,1,1-Trichloroethane	1800	1.8		340	0.34		12000	12		6100	6.1		1100	1.1		390	0.39		250	0.25		250	0.25	
1,1,2,2,-Tetrachloroethane	25	0.025	U	17	0.017	U	160	0.16	U	800	0.8	U	310	0.31	U	80	0.08	U	79	0.079	U		0	U
1,1,2-Trichloroethane	25	0.025	U	17	0.017	U	160	0.16	U	800	0.8	U	310	0.31	U	80	0.08	U	79	0.079	U		0	U
1,1-Dichloroethane	2100	2.1		520	0.52		480	0.48		830	0.83		1100	1.1		210	0.21		230	0.23		240	0.24	
1,1-Dichloroethene	3000	3		1100	1.1		13000	13		22000	22		8600	8.6		1500	1.5		1600	1.6		1500	1.5	
1,2-Dichloroethane	25	0.025	U	17	0.017	U	160	0.16	U	800	0.8	U	310	0.31	U	80	0.08	U	79	0.079	U		0	U
1,2-Dichloropropane	25	0.025	U	17	0.017	U	160	0.16	U	800	0.8	U	310	0.31	U	80	0.08	U	79	0.079	U		0	U
2-Butanone	100	0.1	U	160	0.16		640	0.64	U	3200	3.2	U	1200	1.2	U	320	0.32	U	320	0.32	U		0	U
2-Hexanone	100	0.1	U	68	0.068	U	640	0.64	U	3200	3.2	U	1200	1.2	U	320	0.32	U	320	0.32	U		0	U
4-Methyl-2-pentanone	100	0.1	U	68	0.068	U	640	0.64	U	3200	3.2	U	1200	1.2	U	320	0.32	U	320	0.32	U		0	U
Acetone	100	0.1	U	810	0.81		1000	1		5500	5.5		2400	2.4		1400	1.4		1700	1.7		1800	1.8	
Benzene	25	0.025	U	17	0.017	U	160	0.16	U	800	0.8	U	310	0.31	U	80	0.08	U	79	0.079	U		0	U
Bromodichloromethane	25	0.025	U	17	0.017	U	160	0.16	U	800	0.8	U	310	0.31	U	80	0.08	U	79	0.079	U		0	U
Bromoform	100	0.1	U	68	0.068	U	640	0.64	U	3200	3.2	U	1200	1.2	U	320	0.32	U	320	0.32	U		0	U
Bromomethane	25	0.025	U	17	0.017	U	160	0.16	U	800	0.8	U	310	0.31	U	80	0.08	U	79	0.079	U		0	U
Carbon disulfide	100	0.1	U	170	0.17		640	0.64	U	3200	3.2	U	1200	1.2	U	330	0.33		320	0.32	U		0	U
Carbon tetrachloride	25	0.025	U	17	0.017	U	160	0.16	U	800	0.8	U	310	0.31	U	80	0.08	U	79	0.079	U		0	U
Chlorobenzene	25	0.025	U	17	0.017	U	160	0.16	U	800	0.8	U	310	0.31	U	80	0.08	U	79	0.079	U		0	U
Chloroethane	140	0.14		17	0.017	U	160	0.16	U	800	0.8	U	310	0.31	U	80	0.08	U	79	0.079	U		0	U
Chloroform	25	0.025	U	17	0.017	U	160	0.16	U	800	0.8	U	310	0.31	U	80	0.08	U	79	0.079	U		0	U
Chloromethane	25	0.025	U	17	0.017	U	160	0.16	U	800	0.8	U	310	0.31	U	160	0.16		79	0.079	U		0	U
Cis-1,2-Dichloroethene	3300	3.3		2100	2.1		2000	2		7400	7.4		10000	10		2600	2.6		3600	3.6		3700	3.7	
Cis-1,3-dichloropropene	25	0.025	U	17	0.017	U	160	0.16	U	800	0.8	U	310	0.31	U	80	0.08	U	79	0.079	U		0	U
Dibromochloromethane	25	0.025	U	17	0.017	U	160	0.16	U	800	0.8	U	310	0.31	U	80	0.08	U	79	0.079	U		0	U
Ethylbenzene	25	0.025	U	48	0.048		890	0.89		1400	1.4		1200	1.2		170	0.17		440	0.44		420	0.42	
Methylene chloride	50	0.05		28	0.028		160	0.16	U	1100	1.1		310	0.31	U	80	0.08	U	79	0.079	U		0	U
Methyl-tert-butyl ethe	100	0.1	U	68	0.068	U	640	0.64	U	3200	3.2	U	1200	1.2	U	320	0.32	U	320	0.32	U		0	U
Naphthalene	100	0.1	U	68	0.068	U	640	0.64	U	3200	3.2	U	1200	1.2	U	320	0.32	U	320	0.32	U		0	U
Styrene	25	0.025	U	17	0.017	U	160	0.16	U	800	0.8	U	310	0.31	U	80	0.08	U	79	0.079	U		0	U
Tetrachloroethene	2800	2.8		1200	1.2		15000	15		17000	17		16000	16		2000	2		4200	4.2		3800	3.8	
Toluene	25	0.025	U	88	0.088		1200	1.2		4000	4		1400	1.4		210	0.21		470	0.47		450	0.45	
Trans 1,2-dichloroethene	110	0.11		68	0.068	U	640	0.64	U	3200	3.2	U	1200	1.2	U	320	0.32	U	320	0.32	U		0	U
Trans-1,3-dichloropropene	25	0.025	U	17	0.017	U	160	0.16	U	800	0.8	U	310	0.31	U	80	0.08	U	79	0.079	U		0	U
Trichloroethene	4600	4.6		4100	4.1		59000	59		150000	150		100000	100		17000	17		26000	26		24000	24	
Vinyl chloride	180	0.18		34	0.034		160	0.16	U	800	0.8	U	310	0.31	U	80	0.08	U	79	0.079	U		0	U
p/m - Xylene	110	0.11		160	0.16		3200	3.2		4600	4.6		4400	4.4		620	0.62		1600	1.6		1500	1.5	
o-Xylene	40	0.04		69	0.069	0.229	870	0.87	4.07	1200	1.2	5.8	1200	1.2	5.6	230	0.23	0.85	530	0.53	2.13	500	0.5	2
		0			0			0			0			0			0			0			0	
TVO (Total VOCs)	18230	18.23		10927	10.927		108640	108.64		221130	221.13		147400	147.4		26820	26.82		40620	40.62		38160	38.16	
TICs																								
Benzene, 1-ethyl-2-methyl																			430					
Benzene, 1,3,5-trimethyl-																			430					
Octane	3100									5500														
Octane, 2-methyl-	1400			270									3700											
Octane, 3-methyl-							1800																	
Octane, 4-methyl-										10000														
Cyclohexane, ethyl-	4300			930			2200						1800						560			470		
Cyclohexane, 1,3-dimethyl-, cis	3700			830			2700												630			570		
Cyclohexane, 1,3-dimethyl-, trans-	1600																							

Sites 4 and 3 Influent Vapor Analytical Results
Bedford NWIRP Site
Bedford, Massachusetts

Date Collected	7/31/03			8/7/03			8/14/03			8/22/03			8/28/03			9/6/03			9/11/03			9/11/2003, Duplicate		
Analyte	ppbv	ppmv	Qual.	ppbv	ppmv	Qual.	ppbv	ppmv	Qual.	ppbv	ppmv	Qual.	ppbv	ppmv	Qual.	ppbv	ppmv	Qual.	ppbv	ppmv	Qual.	ppbv	ppmv	Qual.
Cyclohexane, 1,4-dimethyl-							2300																	
Cyclohexane, 1,4-dimethyl-, cis				330			1800																	
Decane, 5,6-dimethyl-				370																				
Decane, 2,6,6-trimethyl-				570																				
Hexane, 2,3,5-trimethyl-	1600																							
Hexane, 1-(hexyloxy)-2-methyl																						480		
Heptane, 2-methyl-				400			2400						2100						560			530		
Heptane, 3-methyl-	1500			400			1700												410					
Heptane, 2,4-dimethyl-																						850		
Heptane, 2,5-dimethyl-							1600																	
Heptane, 2,6-dimethyl-	2800			640			4200																	
Heptane, 3-ethyl-2-methyl-	2400																							
Pentane, 2-methyl-										9600														
2-Propanol										13000														
Nonane	2800			690			2200						3000						400					
Undecane										4500														
Undecane, 5,7-dimethyl-										17000														
Undecane, 2,7-dimethyl-										25000														
Nonadecane, 4-methyl-										6800														
Dodecane										7300														
Hydroxylamine, O-decyl-																			910					
Nonahexacontanoic acic																			720					
Unknown										4900			8100			730			670			1240		
Methane	0.67%			0.014%			0.012%			NA			NA			NA			NA			NA		

Notes
U = Non-detect
J = Analyte was detected below its reporting limit. The result was estimated.
NA = Not analyzed
TIC = Tentatively identified compound

TTFW collected samples and obtained analytical results

APPENDIX A

Laboratory Reports

Site 4 ERH Remediation

Raw Analytical Data and Field Documentation have been removed from this appendix and will be submitted in a separate volume at a later date.

APPENDIX B

Memorandums, Field Logs and Construction Reports

Site 4 ERH Remediation

APPENDIX B

Memorandums

Thermal Remediation Services, Inc.

Site 4 ERH Remediation

THERMAL REMEDIATION services inc.

June 19, 2003

Joe Francis
Foster Wheeler Environmental Corporation
133 Federal St., 6th Floor
Boston, MA 02110

Subject: **Contaminated Region at Site 4 of the Bedford NWIRP**

Dear Mr. Francis:

As you are aware, the newly installed monitoring wells at Site 4 were recently sampled. This sampling provided somewhat surprising results in that the region of contamination is larger and appears to be shifted further south than originally believed when the electrical resistance heating (ERH) remediation system was designed.

The most contaminated well was MW-65s, which contained 320 µg/ℓ of benzene. This is especially troubling because MW-65s is at the upgradient edge of the new MWs and is located about 30 feet downgradient of the former underground storage tank location. MW-65s might indicate that even greater levels of contamination would be found a little further south.

TRS believes that ERH is a powerful site remediation tool. However, ERH will only remediate the region in which it is applied. None of us (Foster-Wheeler, the US Navy, or TRS) would be well served by a very thorough remediation of only a portion of the remaining contaminated zone, especially if residual upgradient benzene were to re-contaminate the treated region. For this reason, TRS strongly urges Foster-Wheeler and the US Navy to make all practical efforts to determine the extent of the contaminated region prior to finalizing the ERH electrode locations and number.

TRS is eager to work with you in order to shift some contracted work into the next fiscal year. However, please note that a delay in start-up of the Site 4 ERH remediation or start-up of the Site 3 pilot test would lead to additional remediation equipment stand-by costs.

Please feel free to contact me at (770) 794-1168 should you have any questions about this letter. Please contact Greg Sandberg at (206) 524-6276 or Tom Powell at (360) 263-3615 if you have questions regarding work that can be deferred or any other measures we can take to provide the best overall remedial approach and cost structure for the site.

Sincerely,

Greg Beyke
VP - Engineering
Thermal Remediation Services

THERMAL REMEDIATION services inc.

April 29, 2004

Mr. Joe Francis
Project Manager
Tetra Tech FW, Inc.
133 Federal St., 6th Floor
Boston, MA 02110

Subject: **Evaluation of Post ERH Groundwater Results at Site 4 of the Bedford NWIRP**

Dear Mr. Francis:

Thank you for forwarding the April 2004 post cool-down analytical data for the Site 4 groundwater monitoring wells at the Bedford NWIRP. TRS has reviewed the data and would like to convey our assessment of these results.

The data provided indicates that all groundwater monitoring wells located down-gradient of the ERH treatment region show a significant decrease in concentration between the end of operations at Site 4 and the April sampling event. These wells include MW-60S, MW-61S, and MW-64S. Additionally, wells MW-62S and MW-42SR, located slightly cross-gradient, show a significant decrease in concentration. The three wells located inside the treatment region, MW-18SR, MW-63S, and MW-65S, all have higher Benzene concentrations than were indicated immediately following ERH application. However, each of these eight monitoring wells remains below the Benzene cleanup concentration objective of 50 µg/ℓ.

The April sample results from monitoring well MW-66S, located up-gradient and outside of the treatment region, indicates higher Benzene concentrations than prior to ERH operations. In fact, this well has the highest Benzene concentration of any well at the Site, 91 µg/ℓ.

TRS believes that groundwater between the Site 4 treatment region and the former UST, located south and up gradient of the treatment region, contains significant Benzene concentrations, as we described in our letter to TfFW dated 19 June, 2003. As this up-gradient groundwater moves into the Site 4 treatment region, it is the likely source of any increase in Benzene concentrations within that region during this post ERH treatment period.

We conclude that the reduced Benzene concentrations indicated in the wells down-gradient of the Site 4 treatment region are attributable to treated groundwater flowing out of the ERH treatment volume in a north/northwesterly direction.

We are interested in hearing whether TfFW shares our view of the results of the post cool-down groundwater analytical data at Site 4. Please feel free to contact me at (817) 741-4361 with any questions or comments you have regarding this evaluation, particularly if you are not in agreement.

Sincerely,
Thermal Remediation Services, Inc.

Jerry L. Wolf
VP - Operations

APPENDIX B

TtFW Field Logs and Construction Reports

Site 4 ERH Remediation

Raw Analytical Data and Field Documentation have been removed from this appendix and will be submitted in a separate volume at a later date.

APPENDIX C

Complete Temperature Interval Data Tables

Site 4 ERH Remediation

Site 4 ERH Remediation
Subsurface Temperature Data
Temperature Monitoring Point (TMP) Locations 1 through 3

Date	Area 4 Average	Area 4 Cell Average							TMP-1							TMP-2							TMP-3						
		-5	-10	-15	-20	-25	-30	AVG.	5	10	15	20	25	30	AVG.	5'	10'	15'	20'	25'	30'	AVG.	5'	10'	15'	20'	25'	30'	AVG.
7/31/03	14	21	15	14	13	12	12	14	22	16	14	12	11	12	13	19	14	15	14	14	13	14	21	16	13	12	11	11	13
8/1/03 7:15	14	22	16	14	13	13	12	14	24	17	14	13	12	12	14	20	15	15	15	14	14	15	22	16	14	12	12	11	14
8/2/03 20:22	16	24	17	16	17	16	14	16	25	18	16	17	16	15	17	22	16	17	18	19	16	18	24	16	14	15	14	12	15
8/3/03 7:51	17	24	17	17	18	18	15	17	26	18	17	18	17	16	18	23	16	18	20	21	17	19	24	17	15	16	16	13	16
8/3/03 18:51	19	25	18	18	20	20	16	19	26	18	19	20	18	17	19	24	17	19	24	25	18	21	24	18	16	17	18	14	17
8/4/03 7:37	20	25	18	19	21	22	17	20	26	19	20	22	21	18	21	24	17	20	24	27	19	22	25	17	16	18	17	14	17
8/4/03 11:45	20	26	18	19	22	22	18	20	27	20	20	22	22	19	21	25	17	20	25	27	19	22	25	17	16	18	18	15	17
8/5/03 7:47	22	26	19	20	24	25	19	22	28	21	22	26	23	20	23	26	18	22	28	32	22	25	24	17	17	19	21	16	19
8/5/03 22:36	24	27	20	22	27	29	22	24	29	22	23	28	29	23	26	27	19	24	31	36	24	28	26	18	18	21	23	18	20
8/6/03 7:37	25	28	20	22	27	31	22	25	29	22	24	29	30	24	26	27	19	25	32	38	25	29	27	18	18	21	24	18	20
8/6/03 14:36	26	28	20	23	28	31	23	26	29	23	25	30	31	25	27	28	19	26	34	39	26	30	27	18	18	21	24	18	20
8/6/03 21:11	26	28	20	24	29	32	24	26	29	23	25	31	32	26	28	28	20	27	34	40	26	30	27	18	19	22	25	19	21
8/7/03 7:26	27	29	21	24	30	33	24	27	30	24	26	32	33	26	29	29	20	28	36	41	27	31	27	19	19	23	26	20	22
8/8/03 17:05	30	30	22	26	33	37	28	30	31	26	28	35	36	30	31	31	22	31	40	46	31	35	27	19	20	25	29	22	23
8/9/03 10:21	31	30	23	27	35	39	29	31	31	26	29	37	38	31	33	31	23	32	42	48	32	36	27	20	21	27	30	23	24
8/9/03 15:22	32	30	23	28	36	40	29	32	31	27	30	38	39	31	34	32	23	33	43	49	33	37	28	20	21	27	31	23	25
8/9/03 17:52	32	30	24	28	36	40	29	32	31	27	30	38	39	32	34	32	24	33	43	49	33	37	27	20	21	27	31	23	25
8/10/03 11:04	33	31	24	29	38	42	31	33	32	27	31	40	41	33	35	33	24	35	45	51	35	39	28	20	22	28	32	24	26
8/11/03	35	31	25	31	40	45	32	35	32	28	34	42	44	35	37	33	25	37	48	55	37	41	29	21	23	30	35	26	27
8/12/03 10:41	37	32	25	33	43	47	34	37	32	29	36	45	47	37	39	34	26	39	51	58	39	44	29	20	24	32	37	27	28
8/13/03 21:44	38	32	27	34	44	48	36	38	33	30	36	46	48	39	40	34	28	40	53	59	41	45	28	22	25	32	38	29	29
8/14/03 8:53	39	32	27	35	45	50	37	39	33	30	37	47	50	39	41	35	28	43	54	61	42	47	29	23	26	34	39	29	31
8/15/03 9:00	40	32	27	35	46	51	38	40	33	30	37	47	50	40	41	35	29	41	55	62	43	47	29	23	27	35	40	30	31
8/15/03 16:00	41	33	28	37	47	51	38	41	33	31	38	49	51	41	42	36	31	45	56	63	44	49	29	23	27	35	40	30	31
8/15/03 19:19	41	33	28	37	47	52	39	41	33	31	38	49	52	41	43	37	31	45	56	63	44	49	29	23	27	35	41	31	32
8/16/03 9:45	42	33	29	38	49	54	39	42	33	31	40	51	54	42	44	37	31	46	58	66	45	50	30	24	28	37	42	31	33
8/16/03 17:53	43	33	29	39	49	55	40	43	33	31	41	51	55	43	45	37	32	47	59	67	46	51	30	24	28	37	43	32	33
8/17/03 1:33	44	34	29	39	50	56	41	44	34	32	41	53	56	44	46	37	32	48	60	68	47	52	31	24	29	38	44	32	34
8/18/03 12:55	45	34	30	41	52	57	42	45	34	32	43	54	57	45	47	37	32	49	62	70	49	53	31	25	30	40	45	33	35
8/18/03	45	34	30	41	52	57	43	45	34	33	43	54	57	45	47	38	33	50	63	70	49	54	30	25	30	40	45	34	35
8/18/03 19:09	45	34	31	41	52	58	43	45	35	33	43	54	58	46	47	38	34	50	63	70	49	54	30	25	30	39	45	34	35
8/19/03 0:16	46	34	31	42	52	58	43	46	35	33	44	54	58	46	47	38	34	51	63	71	49	55	30	25	30	40	45	34	35
8/19/03 8:45	46	35	31	42	53	59	43	46	35	33	44	55	59	46	48	38	34	51	64	72	50	55	31	25	30	40	46	34	35
8/19/03 10:19	46	35	31	42	53	59	43	46	35	34	44	55	59	46	48	38	34	52	65	72	50	56	31	25	30	40	46	34	35
8/19/03 18:55	46	35	31	41	53	59	44	46	35	34	44	55	59	47	48	39	35	50	64	72	50	55	30	25	30	40	46	35	35
8/19/03 22:03	46	35	31	42	54	59	44	46	35	34	44	55	59	47	48	39	35	50	65	72	50	56	31	25	31	41	46	35	36
8/20/03 11:02	47	35	32	42	54	60	44	47	35	34	45	56	60	47	49	39	35	51	66	73	51	56	31	26	31	41	47	35	36
8/20/03 14:51	47	35	32	43	54	60	45	47	35	34	45	56	60	48	49	39	35	52	66	73	52	57	31	26	31	41	47	35	36
8/20/03 17:27	48	35	32	43	55	60	45	48	35	35	46	57	60	48	50	39	36	53	66	74	52	57	31	26	31	42	47	36	37
8/21/03 10:14	49	35	33	44	56	61	46	49	35	35	47	58	61	48	50	39	36	53	68	75	53	58	31	27	32	42	48	36	37
8/21/03 18:43	48	35	33	44	55	61	46	48	35	35	46	57	61	49	50	39	37	53	67	75	53	58	30	26	32	42	48	36	37
8/22/03 0:01	49	35	33	44	56	62	46	49	35	35	47	58	62	49	51	39	37	54	68	75	53	59	31	27	32	43	49	37	38
8/22/03 10:20	50	35	33	46	57	63	47	50	35	35	48	59	63	49	51	39	37	56	69	77	54	60	32	27	33	44	49	37	38
8/22/03 13:52	50	35	33	46	58	64	47	50	35	36	48	60	64	50	52	39	37	57	70	78	54	61	31	27	33	44	50	37	39
8/22/03 17:31	50	35	33	46	58	64	48	50	35	36	48	60	64	50	52	40	37	57	70	78	55	61	31	27	33	44	50	38	39
8/23/03 1:12	51	36	34	46	60	65	48	51	35	36	49	61	66	51	53	40	38	56	71	79	55	61	32	27	34	47	51	38	40
8/23/03 9:07	52	36	33	46	60	67	48	52	36	36	50	62	67	51	54	39	37	55	73	81	56	62	32	27	34	46	52	38	40
8/23/03 13:04	52	36	34	46	61	67	49	52	36	36	50	63	67	52	54	40	38	55	74	82	57	62	33	28	34	46	52	39	40

Site 4 ERH Remediation
Subsurface Temperature Data
Temperature Monitoring Point (TMP) Locations 1 through 3

Date	Area 4 Average	Area 4 Cell Average							TMP-1							TMP-2							TMP-3						
		-5	-10	-15	-20	-25	-30	AVG.	5	10	15	20	25	30	AVG.	5'	10'	15'	20'	25'	30'	AVG.	5'	10'	15'	20'	25'	30'	AVG.
8/23/03 17:11	53	36	34	47	61	68	50	53	36	37	51	63	68	53	55	40	38	55	74	83	57	63	32	27	34	47	53	39	40
8/24/03 1:22	53	37	35	47	63	69	50	53	36	37	52	65	69	53	56	41	39	55	76	84	58	64	33	28	34	48	54	40	41
8/24/03 9:48	55	37	34	48	65	71	51	55	36	37	53	67	71	54	57	40	38	56	78	87	59	65	34	28	35	49	55	41	42
8/24/03 18:15	55	37	35	48	66	73	53	55	37	37	54	68	73	56	58	41	39	56	80	88	60	66	34	28	35	50	57	42	43
8/24/03 23:08	57	38	35	49	68	74	53	57	37	38	55	70	75	57	60	42	40	58	82	90	61	68	34	28	35	51	58	42	43
8/25/03 12:32	59	38	36	50	71	77	55	59	37	38	55	73	78	59	61	42	40	60	88	94	64	71	35	29	36	53	60	43	45
8/25/03 15:26	59	38	36	50	71	78	55	59	37	38	54	73	78	59	61	42	40	60	88	95	64	71	35	29	36	53	60	43	45
8/25/03 18:54	59	38	36	51	72	78	56	59	37	38	56	74	79	60	62	43	41	60	88	95	64	71	35	29	36	54	60	44	45
8/25/03 20:55	60	38	36	51	73	79	56	60	37	39	58	75	80	60	63	43	41	60	89	96	65	72	35	29	36	54	61	44	45
8/26/03 3:07	60	39	36	51	74	80	57	60	37	38	57	76	81	61	63	43	41	61	91	97	66	73	36	29	36	55	62	45	46
8/26/03 11:55	61	39	37	53	75	81	58	61	37	39	60	77	82	62	65	43	41	62	92	98	67	73	36	30	37	55	62	45	46
8/26/03 12:53	61	39	36	53	75	81	58	61	37	39	61	77	82	62	65	43	41	62	93	98	67	74	36	29	37	55	62	45	46
8/26/03 22:39	62	39	37	54	76	82	59	62	37	39	62	78	83	63	66	44	42	63	93	99	67	74	35	30	37	56	63	46	47
8/27/03 10:01	64	39	38	55	80	84	61	64	37	40	58	81	86	65	66	44	43	69	100	102	70	79	36	30	38	58	65	47	48
8/27/03 14:54	65	39	38	56	81	85	61	65	37	40	58	82	87	66	67	44	43	73	101	103	70	80	36	30	38	59	66	47	48
8/27/03 17:56	66	39	38	58	82	86	62	66	37	40	58	83	88	67	67	45	44	79	102	104	71	82	36	30	38	60	67	48	49
8/27/03 20:06	67	40	38	60	81	87	62	67	37	40	58	83	89	67	68	45	44	84	101	104	71	83	37	30	38	60	67	48	49
8/28/03 7:08	70	40	40	65	84	90	64	70	37	41	59	87	92	69	70	45	48	97	102	107	73	89	38	31	39	63	70	50	51
8/28/03 11:24	69	40	40	64	84	89	64	69	37	41	59	87	92	69	70	45	48	94	101	106	73	87	38	31	39	63	70	50	51
8/28/03 19:36	71	40	41	66	85	90	65	71	37	41	60	89	94	71	71	46	52	99	101	106	74	90	38	31	40	65	71	51	52
8/29/03 2:12	72	40	45	67	86	91	66	72	37	41	61	91	95	72	72	46	63	100	101	107	75	93	38	31	40	66	72	51	52
8/29/03 14:03	74	41	47	68	88	92	67	74	37	42	63	93	97	74	74	47	68	101	101	106	76	94	38	32	41	69	74	52	54
8/29/03 16:04	74	41	47	68	88	92	67	74	37	42	63	93	97	74	74	47	68	101	101	106	76	94	38	32	41	69	74	52	54
8/29/03 19:38	74	41	48	69	88	93	68	74	37	42	64	94	98	74	75	47	70	101	101	106	77	95	38	32	41	70	74	53	54
8/29/03 22:49	75	41	49	69	90	93	68	75	37	42	64	95	99	75	75	47	72	102	102	106	77	96	39	32	41	72	75	53	55
8/30/03 2:35	76	41	49	69	92	94	69	76	37	42	65	97	100	76	76	47	74	102	102	107	78	96	39	32	41	76	76	54	56
8/30/03 12:17	76	41	49	70	92	93	69	76	37	43	66	99	100	76	77	47	72	101	101	103	78	94	39	33	42	75	76	54	57
8/30/03 20:37	77	41	50	70	93	94	71	77	37	43	68	100	102	78	78	48	74	101	101	103	79	95	39	33	42	77	78	55	58
8/31/03 2:53	78	41	51	73	94	95	71	78	37	43	75	100	103	79	80	48	76	102	102	103	80	96	39	33	43	80	79	55	59
8/31/03 19:55	78	41	51	75	93	95	72	78	37	44	80	100	103	80	82	48	75	101	101	102	80	95	39	33	43	79	80	56	59
9/1/03 15:22	79	41	51	78	94	95	73	79	36	44	89	99	103	82	84	48	76	101	101	101	81	95	39	34	44	81	80	57	60
9/1/03 21:44	80	41	52	79	94	95	74	80	36	45	92	100	103	83	85	49	77	101	101	102	81	95	39	34	45	81	81	58	60
9/2/03 1:31	80	41	52	79	94	96	74	80	36	45	91	100	104	83	85	49	77	102	101	102	82	96	39	34	45	81	81	58	60
9/2/03 8:50	80	42	52	79	94	95	75	80	36	45	91	99	103	84	85	49	77	100	101	101	82	95	40	34	45	82	81	58	61
9/3/03 8:00	78	40	50	74	93	95	74	78	35	45	77	99	102	83	81	48	70	99	100	102	82	93	38	35	46	80	80	58	60
9/3/03 18:39	76	40	48	72	92	94	74	76	36	45	76	99	102	83	81	48	63	94	99	102	81	90	37	35	46	77	79	58	59
9/3/03 21:39	76	40	47	71	92	94	75	76	36	45	75	99	102	84	80	48	62	93	100	102	82	89	37	35	46	78	79	58	60
9/4/03 8:05	78	40	48	75	93	96	75	78	35	45	78	100	104	84	82	47	64	99	101	104	82	92	38	35	47	77	80	59	60
9/4/03 14:29	80	40	51	77	93	97	76	80	35	46	83	100	105	85	84	47	71	100	101	105	83	94	38	36	48	78	81	60	61
9/4/03 23:22	79	40	51	76	93	96	76	79	35	45	81	101	104	85	83	47	73	99	100	105	83	94	38	36	48	78	80	59	61
9/5/03 4:54	80	40	52	77	93	97	76	80	35	46	83	101	105	86	84	47	74	100	101	105	83	95	38	36	48	78	81	60	61
9/5/03 17:08	79	40	52	75	93	96	76	79	35	46	78	100	104	85	82	47	74	100	100	104	83	95	37	36	48	78	80	60	61
9/6/03 10:59	84	40	55	84	96	99	77	84	35	46	96	104	107	87	88	47	83	102	104	109	85	100	38	37	54	79	82	60	63
9/6/03 23:38	85	40	55	87	97	100	78	85	35	47	98	104	108	88	89	48	82	103	103	109	86	99	38	37	60	83	83	61	66
9/7/03 12:19	85	41	56	88	96	100	79	85	35	48	98	103	108	89	89	48	81	103	103	108	86	99	39	38	62	82	83	61	66
9/7/03 18:48	85	40	56	89	96	100	79	85	35	48	98	103	108	89	89	48	82	103	103	108	86	99	38	38	66	81	84	62	67
9/8/03 6:07	84	40	56	85	95	99	79	84	35	49	91	102	107	89	87	48	81	101	102	107	87	98	38	39	62	81	83	62	66
9/8/03 14:44	85	40	57	86	96	100	80	85	35	49	91	102	107	90	87	48	81	101	104	108	87	99	38	40	66	81	84	62	68

Site 4 ERH Remediation
Subsurface Temperature Data
Temperature Monitoring Point (TMP) Locations 1 through 3

Date	Area 4 Average	Area 4 Cell Average							TMP-1							TMP-2							TMP-3						
		-5	-10	-15	-20	-25	-30	AVG.	5	10	15	20	25	30	AVG.	5'	10'	15'	20'	25'	30'	AVG.	5'	10'	15'	20'	25'	30'	AVG.
9/9/03 1:23	85	41	58	87	97	100	80	85	35	49	93	102	107	91	88	49	84	102	104	109	88	100	39	40	67	84	84	62	69
9/9/03 6:35	85	41	58	87	97	100	80	85	35	49	94	102	107	91	88	49	84	102	103	108	88	99	39	41	66	85	84	62	69
9/9/03 16:21	84	41	59	84	95	98	80	84	35	50	87	101	105	91	86	49	87	102	102	105	88	99	39	41	64	83	84	62	68
9/10/03 4:38	85	42	60	86	96	98	81	85	35	50	90	102	106	92	87	50	87	103	103	105	88	100	40	42	64	84	84	62	69
9/11/03 9:23	83	42	60	83	95	96	80	83	35	51	83	100	104	91	85	50	83	101	101	102	87	97	40	45	65	83	83	62	69
9/12/03 12:23	85	42	61	86	96	99	81	85	35	51	88	102	106	92	87	51	86	102	103	108	88	100	40	46	67	83	83	63	70
9/13/03 2:15	86	43	62	88	96	99	82	86	35	52	91	102	106	93	88	52	87	102	102	107	89	100	41	47	72	85	84	64	72
9/14/03 14:17	87	44	64	92	96	97	82	87	36	56	97	99	104	95	89	53	87	102	102	103	88	99	43	50	78	86	83	63	74
9/14/03 23:57	88	45	66	94	95	96	82	88	36	61	99	99	103	95	91	54	87	102	101	103	88	98	44	51	82	86	83	63	76
9/15/03 7:57	89	45	68	96	95	96	82	89	36	65	99	99	103	95	92	54	87	102	101	103	87	98	44	52	87	86	82	63	77
9/16/03 7:33	90	45	72	99	95	94	81	90	36	72	99	99	99	93	92	55	89	102	100	101	86	98	44	56	97	86	82	63	80
9/17/03 8:31	85	45	73	98	95	94	81	85	36	74	99	99	99	95	93	55	85	101	101	101	86	89	45	59	94	86	81	62	73
9/18/03 7:16	88	45	71	94	94	93	80	88	36	73	99	99	98	94	92	56	81	100	100	100	85	95	44	60	83	84	80	62	77
9/19/03 7:32	86	45	68	91	94	93	79	86	36	65	94	98	99	92	89	55	79	99	100	100	84	95	44	61	79	83	79	62	76
9/20/03 12:13	93	46	76	100	97	98	81	93	36	71	99	100	106	94	94	55	91	101	101	108	87	100	46	67	99	91	81	62	85
9/21/03 23:30	90	47	74	95	95	95	81	90	37	68	97	99	102	94	92	57	89	101	100	101	87	98	46	65	87	87	81	63	80
9/22/03 11:16	92	47	75	99	98	97	82	92	38	67	98	101	105	94	93	57	91	102	102	104	88	100	47	66	98	91	81	63	84

APPENDIX B

Photographic Documentation

ERH Remediation
Bedford NWIRP Site
Bedford, Massachusetts

PHOTOGRAPHIC RECORD

Direction of View:
_ Northeast _
Date:
5/1/02

Description:
Site 4 ERH Pilot Test Area. Treatment area is outlined in white. Electrode locations are marked in orange, and monitoring wells in white.

Direction of View:
West
Date:
5/1/02

Description:
Site 4 ERH Pilot Test Area. Treatment area is outlined in white. Electrode locations are marked in orange, and monitoring wells in white.

ERH Remediation
Bedford NWIRP Site
Bedford, Massachusetts

PHOTOGRAPHIC RECORD

Direction of View:
North
Date:
7/14/03

Description:
Drill rig and related
Equipment set up on
electrode 1, while
advancing 10" casing.

Direction of View:
North
Date:
5/15/03

Description:
Advancing of 6" steel
casing at MW-61S

ERH Remediation
Bedford NWIRP Site
Bedford, Massachusetts

PHOTOGRAPHIC RECORD

Direction of View:
_ Not Applicable _
Date:
___6/14/03______

Description:
Bottom of typical _______ electrode, ready to be ____ installed in boring.______

Direction of View:
_ __North___ _
Date:
___7/14/03______

Description:
Installation of uppermost_ section of electrode 2 into_ boring.________________

ERH Remediation
Bedford NWIRP Site
Bedford, Massachusetts

PHOTOGRAPHIC RECORD

Direction of View:
__North____ _
Date:
_7/14/03_____

Description:
Adding graphite sand for _ annular space of electrode_ conductive interval of ___ electrode 2.____________

Direction of View:
_Not applicable _
Date:
___6/3/03______

Description:
Closeup of graphite sand _ used for filling annular ___ space of electrodes.______

ERH Remediation
Bedford NWIRP Site
Bedford, Massachusetts

PHOTOGRAPHIC RECORD

Direction of View:
_Not applicable _
Date:
___6/3/03______

Description:
Closeup of steel shot used_ for filling annular space__ of electrodes.___________

Direction of View:
_Not applicable _
Date:
___6/3/03______

Description:
Closeup of screened _____ interval material used for _ electrode construction.___

ERH Remediation
Bedford NWIRP Site
Bedford, Massachusetts

PHOTOGRAPHIC RECORD

Direction of View:
Not applicable
Date:
6/14/03

Description:
Newly installed electrode, without CPVC protective casing yet placed over it.

Direction of View:
Not applicable
Date:
7/14/03

Description:
Top of typical electrode, with threaded opening for VR pipe connection and opening for bolt connection of electrode cable.

ERH Remediation
Bedford NWIRP Site
Bedford, Massachusetts

PHOTOGRAPHIC RECORD

Direction of View:
_Not applicable _
Date:
___7/18/03_____

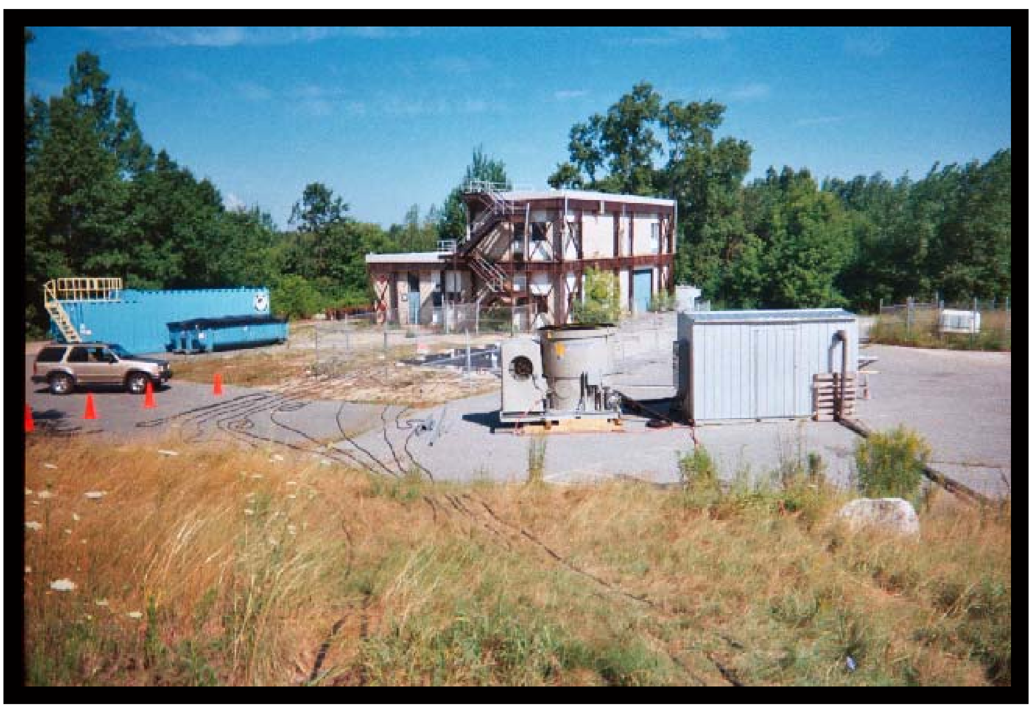
Description:
Completed electrode, with cable, VR pipe, and water drip tubing shown.______

Direction of View:
___North_ _
Date:
_7/24/03____

Description:
Site 4 ERH treatment area. TMP within monitoring__ well casing seen in ______ foreground. Electrode___ oversleeves are placed on_ electrodes.____________

Direction of View:
__Southeast_ _
Date:
__Unknown___

Description:
Aerial view of Site 4 ERH treatment region, _______ consisting of eight ______ electrodes.____________



Direction of View:
__North_ _
Date:
Unknown

Description:
ERH treatment region.___ In foreground is cooling__ tower (left) and condenser unit (right). VR piping runs from condenser unit_ towards Site 3. _________

ERH Remediation
Bedford NWIRP Site
Bedford, Massachusetts

PHOTOGRAPHIC RECORD

Direction of View:
____West___ _
Date:
___7/10/03____

Description:
Vapor-phase GAC vessels_
with hose connections.___

Direction of View:
__North_ _
Date:
Unknown

Description:
Cooling tower (left) and__
condenser unit (right).___

ERH Remediation
Bedford NWIRP Site
Bedford, Massachusetts

PHOTOGRAPHIC RECORD

Direction of View:
__South_ _
Date:
_5/1/03___

Description:
Power control unit, after__ delivery to site.   Location is adjacent to Components Building.______________

Direction of View:
__North__ _
Date:
_5/30/03___

Description:
Groundwater sampling set-up for Site 4 pre-treatment groundwater sampling.___

ERH Remediation
Bedford NWIRP Site
Bedford, Massachusetts

PHOTOGRAPHIC RECORD

Direction of View:
___West___

Date:
_9/10/03___

Description:
Groundwater sampling equipment setup for hot groundwater sampling during ERH treatment. Well being purged is MW-56I. (An identical setup was utilized for Site 4 hot groundwater sampling.

Direction of View:
Not applicable

Date:
_9/10/03___

Description:
Groundwater sampling equipment setup for hot groundwater sampling during ERH treatment. Well being purged is MW-56I. Note ice bath for cooling sample during purging.

APPENDIX C

Monitoring Well Soil Boring Logs and Construction Details

BORING NUMBER: MW-60S

FIELD BORING LOG SHEET

PROJECT:	Bedford NWIRP - ERH Thermal Treatment, Site 4	DATE STARTED:	5/14/03
PROJECT NO.:	2282.0892	DATE COMPLETED:	5/14/03
LOCATION:	North end of treatment area	GROUDWATER DEPTH:	20.30' TIC on 5/29/03
		GROUND ELEVATION:	
GEOLOGIST:	Matthew Greenberg	X COORDINATE:	
DRILLER:	Bowser-Morner, Inc.	Y COORDINATE:	
DRILLING/SAMPLING METHOD:	Rotosonic Drilling/plastic bag sample at 0-9', lexan liner samples at 10-30'.	DATUM:	

Sample ID	Depth (feet)	BLOWS per 6"	Recov-ery (in)	USCS	Description	Time	Date	FID (ppm)	Comments
	1-9		65		0-12" Asphalt. 12-24" Tan silty SAND; some ang f-c gravel; trace clay; moist; dense. 24-27" Dk gray SILT; little ang f-c gravel; moist; dense. 27-37" Olive gravelly (ang, f-c) SILT; moist; dense. 37-44" Dk gray fm SAND; moist; semi-loose. 44-54" M brown silty f-m SAND; trace subrounded mc gravel; moist; semi-loose. 54-65" Rock fragment.	1442	5/14/03	1.5	
	9-10		N/A		Core through rock/boulder from 9-10 feet.	1505	5/14/03	N/A	
	10-15		18		0-15" Orange-brown m-c SAND; little subang f-c gravel; semi-dense; wet.	1525	5/14/03	NAB	
	15-20		41		0-8" Orange-brown m-c SAND; little subang f-c gravel; semi-dense; wet.	1600	5/14/03	See right.	Highest FID reading= 7.1 ppm at 3.0 ft.
	20-25		31		0-17" Lt brown silty f-c SAND; some rounded f-c gravel; wet; dense. 17-31" Gray gravelly SILT; trace to some sand; dry; v dense.	1620	5/14/03	See right.	Highest FID reading= 1000 ppm at 2.0 ft.
MW-60S-SBC-051403	25-30		60		Gray gravelly SILT; trace to some sand; dry; v dense.	1645	5/14/03	See right.	Sample collected at 25.5 ft bgs. Highest FID reading= 3466 ppm at 0.5 ft.
					End of boring at 30 feet.				

NOTES: N/A = Not applicable. NAB = Not above background. ft = feet.
bgs = below ground surface. TIC = top of inner casing.

BORING NUMBER: MW-61S

FIELD BORING LOG SHEET

PROJECT: Bedford NWIRP - ERH Thermal Treatment, Site 4
PROJECT NO.: 2282.0892
LOCATION: Northwest corner of treatment area
GEOLOGIST: Matthew Greenberg
DRILLER: Bowser-Morner, Inc.
DRILLING/SAMPLING METHOD: Rotosonic Drilling/plastic bag sample at 0-9', lexan liner samples at 10-30'.

DATE STARTED: 5/15/03
DATE COMPLETED: 5/15/03
GROUDWATER DEPTH: 17.59' TIC on 5/29/03
GROUND ELEVATION:
X COORDINATE:
Y COORDINATE:
DATUM:

Sample ID	Depth (feet)	BLOWS per 6"	Recov-ery (in)	USCS	Description	Time	Date	FID (ppm)	Comments
	0-10"		N/A		Asphalt.	1043	5/15/03	N/A	
	10"-10'		57		0-26" Lt brown silty f-m SAND; trace subang-ang f-c gravel; moist. 26-57" Brown f-m SAND; trace ang m gravel; moist.	1100	5/15/03	0.0	
	10-15		60		0-12" Lt brown silty f-m SAND; trace subang-and f-c gravel; moist. 12-60" Lt brown silty f SAND; little m-c sand; trace subrounded f-c gravel; moist; v dense.	1115	5/15/03	See right.	Highest FID reading= 0.1 ppm at 1.5 ft.
MW-61S-SBA-051503	15-20		60		0-36" Lt brown silty f SAND; little m-c sand; trace subrounded f-c gravel; moist; v dense becomes satd at 18.5 ft.	1125	5/15/03	See right.	Highest FID reading= 2900 ppm at 5.0 ft. Sample collected at 20 ft bgs.
	20-25		60		0-12" Orange f-c SAND; trace silt and rounded f-c gravel; wet to satd; v dense. 12-60" Gray SILT; little clay and subrounded to rounded f-c gravel; moist to wet; v dense.	1205	5/15/03	See right.	Highest FID reading= 2300 ppm at 0.5 ft.
	25-30		58		Gray SILT; trace sand; little subrounded to rounded f-c gravel and clay; moist to wet; v dense.	1215	5/15/03	See right.	Highest FID reading= 2.2 ppm at 0.5 ft.
					End of boring at 30 feet.				

NOTES: N/A = Not applicable.
NAB = Not above background.
ft = feet.
bgs = below ground surface.
TIC = top of inner casing.

BORING NUMBER: MW-62S

FIELD BORING LOG SHEET

PROJECT: Bedford NWIRP - ERH Thermal Treatment, Site 4
PROJECT NO.: 2282.0892
LOCATION: Northeast corner of treatment area

GEOLOGIST: Matthew Greenberg
DRILLER: Bowser-Morner, Inc.
DRILLING/SAMPLING METHOD: Rotosonic Drilling/plastic bag sample at 0-10', lexan liner samples at 10-30'.

DATE STARTED: 5/15/03
DATE COMPLETED: 5/15/03
GROUDWATER DEPTH: 17.79' TIC on 5/29/03
GROUND ELEVATION:
X COORDINATE:
Y COORDINATE:
DATUM:

Sample ID	Depth (feet)	BLOWS per 6"	Recov-ery (in)	USCS	Description	Time	Date	FID (ppm)	Comments
	0-0.5		N/A		Asphalt.	1523	5/15/03		
	0.5-5		50		0-35" Lt brown f-m SAND; trace subrounded f-m gravel; moist; dense. 35-50" Dk gray f SAND; trace silt; moist; semi-loose.	1550	5/15/03	0.0	
	5-10		28		0-12" Dk gray f SAND; trace silt; moist; semi-loose. 12-21" COBBLE. 21-28" Lt brown f-m SAND; moist; loose.	1610	5/15/03	0.0	
	10-15		28		0-20" Dk gray silty m-c subang GRAVEL; dry; loose. 20-28" Orange-brown silty f-m SAND; little subang f-m gravel; moist; v dense.	1610	5/15/03	0.0	
	15-20		31		0-18" Lt gray-brown silty f-c SAND; little subang f-c gravel; dry; dense. 18-31" Gray SILT; some f sand; little clay; wet; v dense.	1620	5/15/03	See right.	Highest FID reading= 234.8 ppm at 1.5 ft.
MW-62S-SBA-051503	20-25		53		0-20" Brown f-m SAND; little subang f-c gravel; dry to wet; v dense. 20-27" Orange silty m SAND; black discoloration at 23-26"; wet; semi-loose. 27-53" Gray SILT; little subrounded f-c gravel; trace sand; moist; v dense.	1630	5/15/03	See right.	Sample collected at 17.5 ft bgs. Highest FID reading= 501 ppm at 1.5 ft.
	25-30		58		Gray SILT; little subrounded f-c gravel; trace sand; moist; v dense.	1700	5/15/03	0.0	
					End of boring at 30 feet.				

NOTES: N/A = Not applicable.
NAB = Not above background.
ft = feet.
bgs = below ground surface.
TIC = top of inner casing.

BORING NUMBER: MW-63S

FIELD BORING LOG SHEET

PROJECT: Bedford NWIRP - ERH Thermal Treatment, Site 4
PROJECT NO.: 2282.0892
LOCATION: Southern edge of treatment area
GEOLOGIST: Matthew Greenberg
DRILLER: Bowser-Morner, Inc.
DRILLING/SAMPLING METHOD: Rotosonic Drilling/plastic bag sample at 0-10', lexan liner samples at 10-30'.

DATE STARTED: 5/16/03
DATE COMPLETED: 5/16/03
GROUDWATER DEPTH: 15.36' TIC on 5/29/03
GROUND ELEVATION:
X COORDINATE:
Y COORDINATE:
DATUM:

Sample ID	Depth (feet)	BLOWS per 6"	Recovery (in)	USCS	Description	Time	Date	FID (ppm)	Comments
	0-5		49		0-13" Brown f-m SAND; trace organics; moist; loose. 13-49" Orange-brown f-m SAND; trace subang f-m gravel; wet; loose.	1525	5/16/03	0.0	
	5-10		36		0-20" Lt brown f-m SAND; little silt; moist; loose. 20-21" Dk brown PEAT; moist. 21-36" Lt brown silty f-c SAND; little subang-ang f-c gravel; wet; semi-loose.	1530	5/16/03	0.0	
	10-15		56		Gray-brown silty f-c SAND; little subang-ang f-c gravel; wet; dense.	1540	5/16/03	See right.	Highest FID reading= 77.7 ppm at 4.0 ft.
MW-63S-SBA-051603	15-20		60		0-36" Orange silty f-c SAND; little subang-ang f-c gravel; wet; dense; satd at 16". 36-60" Gray SILT; little subrounded f-c gravel; moist; v dense.	1550	5/16/03	See right.	Highest FID reading= 1938 ppm at 2.5 ft. Sample collected at 17.5 ft bgs.
	20-25		60		Gray SILT; little subrounded f-c gravel; moist; v dense.	1605	5/16/03	See right.	Highest FID reading= 390 ppm at 1.0 ft.
	25-30		57		Same as above.	1640	5/16/03		
					End of boring at 30 feet.				

NOTES: N/A = Not applicable.
NAB = Not above background.
ft = feet.
bgs = below ground surface.
TIC = top of inner casing.

BORING NUMBER: MW-64S

FIELD BORING LOG SHEET

PROJECT: Bedford NWIRP - ERH Thermal Treatment, Site 4
PROJECT NO.: 2282.0892
LOCATION: Southwest corner of treatment area

GEOLOGIST: Matthew Greenberg
DRILLER: Bowser-Morner, Inc.
DRILLING/SAMPLING METHOD: Rotosonic Drilling/plastic bag sample at 0-10' and 13.5-20', lexan liner samples at 10-13.5' and 20-30'.

DATE STARTED: 5/16/03
DATE COMPLETED: 5/16/03
GROUDWATER DEPTH: 14.95' TIC on 5/29/03
GROUND ELEVATION:
X COORDINATE:
Y COORDINATE:
DATUM:

Sample ID	Depth (feet)	BLOWS per 6"	Recovery (in)	USCS	Description	Time	Date	FID (ppm)	Comments
	0-5		14"		0-4" Gray organic SILT; moist; loose. 4-14" Brown SILT; trace ang f-m gravel; dry; loose.	0930	5/16/03	0.0	Cobble at base caused low recovery.
	5-10		24"		0-11" M brown f-m SAND; little silt; trace f-m subrounded gravel; moist; dense. 11-24" Rock, cored.	0945	5/16/03	0.0	
	10-13.5		12"		Rock fragments.	1055	5/16/03	N/A	
MW-64S-SBA-051603	13.5-20		49"		0-20" Lt brown SILT; trace subrounded f-m gravel; dry; loose. 20-49" Orange-brown silty f-m SAND; little subrounded f-m gravel; wet to satd; semi-dense.	1105	5/16/03	See right.	Highest FID reading= 2850 ppm at 3.0 ft. Sample collected at 16.5 ft bgs.
	20-25		57"		Gray SILT; little subrounded f-c gravel; trace sand; moist; v dense.	1125	5/16/03	0.0	
	25-30		60"		Same as above.	1145	5/16/03	0.0	
					End of boring at 30 feet.				

NOTES: N/A = Not applicable.
NAB = Not above background.
ft = feet.
bgs = below ground surface.
TIC = top of inner casing.

BORING NUMBER: MW-65S

FIELD BORING LOG SHEET

PROJECT: Bedford NWIRP - ERH Thermal Treatment, Site 4
PROJECT NO.: 2282.0892
LOCATION: South end of treatment area

GEOLOGIST: Joseph Francis
DRILLER: Bowser-Morner, Inc.
DRILLING/SAMPLING METHOD: Rotosonic Drilling/plastic bag sample at 0-10' and 20-25', lexan liner samples at 10-20' and 25-30'.

DATE STARTED: 5/17/03
DATE COMPLETED: 5/17/03
GROUDWATER DEPTH: 11.25' TIC on 5/29/03
GROUND ELEVATION:
X COORDINATE:
Y COORDINATE:
DATUM:

Sample ID	Depth (feet)	BLOWS per 6"	Recov-ery (in)	USCS	Description	Time	Date	FID (ppm)	Comments
	0-5		40		0-8" Dk brown Topsoil and sandy GRAVEL. 8-14" Silty CLAY. 14-40" Lt brown and tan SAND.	0820	5/17/03	0.0	
	5-10		42		0-6" Lt brown and tan SAND. 6-12" Sandy GRAVEL. 12-42" Orange and brown coarse SAND.	0825	5/17/03	0.0	
	10-15		60		0-4" Dk brown SAND. 4-35" Red-tan c SAND with gravel. 35-43" Gray-brown SAND. 43-60" Lt brown m SAND.	0838	5/17/03	See right.	Highest FID reading= 1600 ppm at 14.5 ft.
MW-65S-SBA-0517103	15-20		60		0-4" SAND. 4-8" Dk gray f SAND; wet.. 8-28" Lt gray-tan TILL. 28-60" Gray TILL.	0851	5/17/03	See right.	Sample collected at 16.0 ft bgs. Highest FID reading= 2130 ppm at 1.0 ft.
	20-25		60		0-23" Gray TILL. 23-33" C SAND. 33-60" TILL.	NR	5/17/03	NR	Lexan tube had gotten jammed; switch to using bag sampler.
	25-30		60		TILL.	1000	5/17/03	0.0	
					End of boring at 30 feet.				

NOTES: N/A = Not applicable.
NAB = Not above background.
ft = feet.
bgs = below ground surface.
NR = Not recorded.
TIC = top of inner casing.

PAGE 1 OF 1

BORING NUMBER: MW-66S

FIELD BORING LOG SHEET

PROJECT:	Bedford NWIRP - ERH Thermal Treatment, Site 4	DATE STARTED:	6/26/03
PROJECT NO.:	2282.0892	DATE COMPLETED:	6/26/03
LOCATION:	South of treatment area; adjacent to former underground storage tank.	GROUDWATER DEPTH:	10.44' TIC on 6/30/03
		GROUND ELEVATION:	
GEOLOGIST:	Joseph Francis	X COORDINATE:	
DRILLER:	Bowser-Morner, Inc.	Y COORDINATE:	
DRILLING/SAMPLING METHOD:	Rotosonic Drilling/plastic bag sample at 0-10', lexan liner samples at 10-25'.	DATUM:	

Sample ID	Depth (feet)	BLOWS per 6"	Recov-ery (in)	USCS	Description	Time	Date	FID (ppm)	Comments
	0-1		N/A		0-12" Asphalt.		6/26/03		
	1-5		40		0-22" Brown fm SAND; moist; loose. 22-40" Orange-brown f-m SAND; little c sand; trace f-m gravel; wet; loose.	0830	6/26/03	2.6	
	5-10		38		0-29" Orange-brown f-m SAND; little c sand; trace f-m gravel; wet; loose. 29-38" Orange-brown f-m SAND; little c sand; trace f-m gravel; gray silt lens at 29"; wet; loose.	0832	6/26/03	32.2	
MW-66S-SBA-062603	10-15		60		0-23" Orange-brown f-m SAND; little c sand; trace f-m gravel; wet; loose. 23-60" Gray-brown silty f-c SAND; little subang-ang f-c gravel; wet; satd at 27-44"; moist at 44-60"; dense.	0845	6/26/03	See right.	Highest FID reading= 433 ppm at 4.5 ft. Sample collected at 14.5 ft bgs.
	15-20		60		0-43" Gray-brown silty f-c SAND; little subang-ang f-c gravel; satd; dense. 43-60" Gray SILT; little subrounded f-c gravel; dry; v dense.	0900	6/26/03	See right.	Highest FID reading= 169 ppm at 3.5 ft.
	20-25		58		0-43" Orange-brown silty f-c SND; satd; v loose. 43-58" Gray SILT; little subrounded f-c gravel; dry; v dense.	0920	6/26/03	143	Sample tube became jammed; plastic bag used for sample.
					End of boring at 25 feet.				

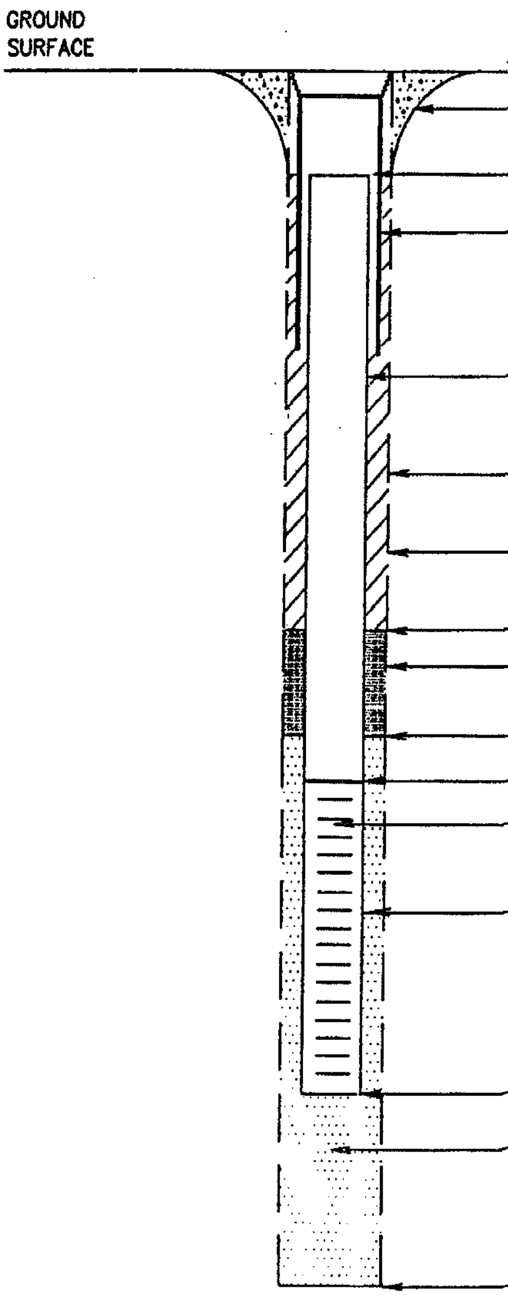
NOTES: N/A = Not applicable. bgs = below ground surface.
NAB = Not above background. NR = Not recorded.
ft = feet. TIC = top of inner casing.

UNCONSOLIDATED
MONITORING WELL
CONSTRUCTION DIAGRAM

WELL NO. MW-18SR

PROJECT: Bedford NWIRP – ERH Thermal Treatment, Site 4
PROJECT NO.: 2282.0892
DATE:
BORING NO.: MW-18SR
ELEVATION:
FIELD GEOLOGIST: Matthew Greenberg

DRILLER: Bowser-Morner, Inc.
DRILLING METHOD: Rotosonic Drilling
DEVELOPMENT METHOD: Whale pump/surge block



NOT TO SCALE

ELEVATION OF TOP OF SURFACE CASING:
TYPE OF SURFACE SEAL: Concrete
GROUND SURFACE ELEVATION:
ELEVATION OF TOP OF RISER:

I.D. OF SURFACE CASING: 8 in
TYPE OF SURFACE CASING: Steel flush Mount

RISER PIPE I.D. 2 in
TYPE OF RISER PIPE: Carbon steel

BOREHOLE DIAMETER: 6 in

TYPE OF BACKFILL: Cement-bentonite grout

ELEVATION/DEPTH TOP OF SEAL: 14 ft
TYPE OF SEAL: Medium size bentonite chips

ELEVATION/DEPTH TOP OF SAND PACK: 16 ft
ELEVATION/DEPTH TOP OF SCREEN: 18 ft

TYPE OF SCREEN: Stainless steel
SLOT SIZE X LENGTH: .020 in X 10 ft
TYPE OF SAND PACK: #5 Quartz sand

ELEVATION/DEPTH BOTTOM OF SCREEN: 28 ft

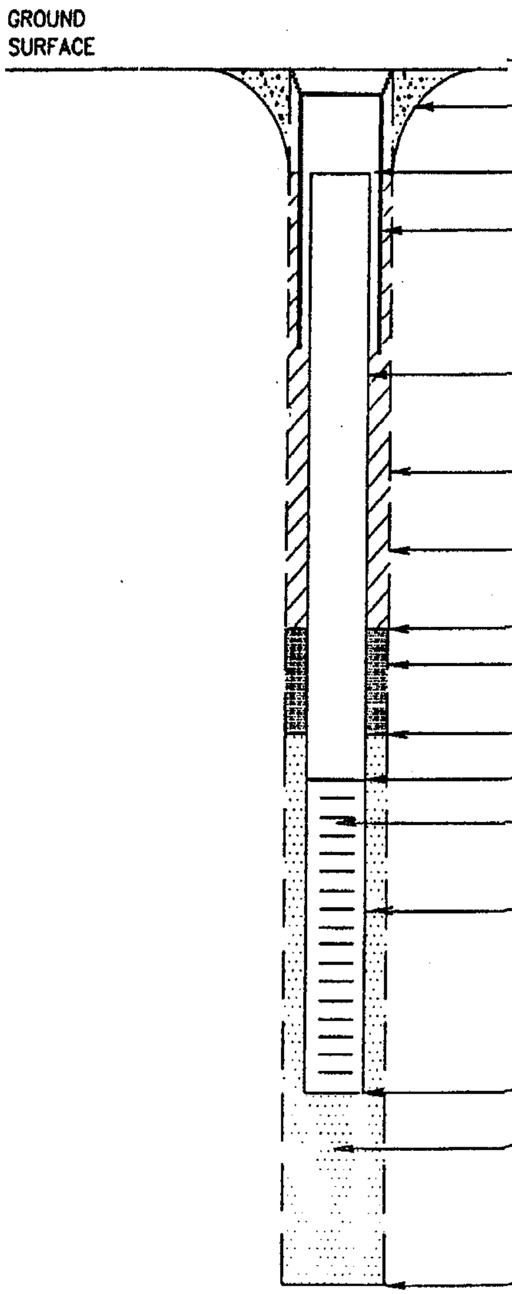
ELEVATION/DEPTH BOTTOM OF SAND PACK: 28 ft
TYPE OF BACKFILL BELOW OBSERVATION WELL: None

ELEVATION/DEPTH OF HOLE: 28 ft

UNCONSOLIDATED MONITORING WELL CONSTRUCTION DIAGRAM

WELL NO. MW-42SR

PROJECT	Bedford NWIRP – ERH Thermal Treatment, Site 4	DRILLER	Bowser-Morner, Inc.
PROJECT NO.	2282.0892	DRILLING METHOD	Rotosonic Drilling
DATE		BORING NO.:	MW-42SR
ELEVATION		DEVELOPMENT METHOD	Whale pump/surge block
FIELD GEOLOGIST	Matthew Greenberg		



ELEVATION OF TOP OF SURFACE CASING:
TYPE OF SURFACE SEAL: Concrete
GROUND SURFACE ELEVATION:
ELEVATION OF TOP OF RISER:

I.D. OF SURFACE CASING: 8 in
TYPE OF SURFACE CASING: Steel flush Mount

RISER PIPE I.D. 2 in
TYPE OF RISER PIPE: Carbon steel

BOREHOLE DIAMETER: 6 in

TYPE OF BACKFILL: Cement-bentonite grout

ELEVATION/DEPTH TOP OF SEAL: 11 ft
TYPE OF SEAL: Medium size bentonite chips

ELEVATION/DEPTH TOP OF SAND PACK: 13 ft
ELEVATION/DEPTH TOP OF SCREEN: 15 ft

TYPE OF SCREEN: Stainless steel
SLOT SIZE X LENGTH: .020 in X 10 ft
TYPE OF SAND PACK: #5 Quartz sand

ELEVATION/DEPTH BOTTOM OF SCREEN: 25 ft

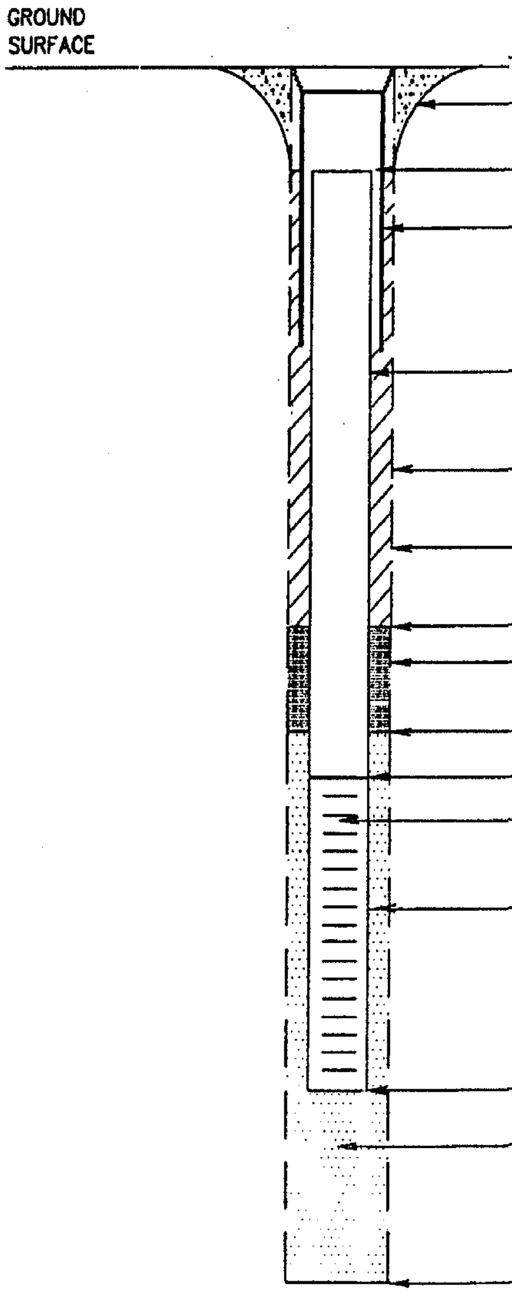
ELEVATION/DEPTH BOTTOM OF SAND PACK: 25 ft
TYPE OF BACKFILL BELOW OBSERVATION WELL: None

ELEVATION/DEPTH OF HOLE: 25 ft

UNCONSOLIDATED MONITORING WELL CONSTRUCTION DIAGRAM

WELL NO. MW-60S

PROJECT: Bedford NWIRP – ERH Thermal Treatment, Site 4	DRILLER: Bowser-Morner, Inc.
PROJECT NO.: 2282.0892	DRILLING METHOD: Rotosonic Drilling
DATE: BORING NO.: MW-60S	DEVELOPMENT METHOD: Whale pump/surge block
ELEVATION:	
FIELD GEOLOGIST: Matthew Greenberg	



ELEVATION OF TOP OF SURFACE CASING:

TYPE OF SURFACE SEAL: Concrete

GROUND SURFACE ELEVATION:

ELEVATION OF TOP OF RISER:

I.D. OF SURFACE CASING: 8 in

TYPE OF SURFACE CASING: Steel flush Mount

RISER PIPE I.D. 2 in

TYPE OF RISER PIPE: Carbon steel

BOREHOLE DIAMETER: 6 in

TYPE OF BACKFILL: Cement-bentonite grout

ELEVATION/DEPTH TOP OF SEAL: 12 ft

TYPE OF SEAL: Medium size bentonite chips

ELEVATION/DEPTH TOP OF SAND PACK: 14 ft

ELEVATION/DEPTH TOP OF SCREEN: 16 ft

TYPE OF SCREEN: Stainless steel

SLOT SIZE X LENGTH: .020 in X 10 ft

TYPE OF SAND PACK: #5 Quartz sand

ELEVATION/DEPTH BOTTOM OF SCREEN: 26 ft

ELEVATION/DEPTH BOTTOM OF SAND PACK: 26 ft

TYPE OF BACKFILL BELOW OBSERVATION WELL: #5 Quartz sand/native soils

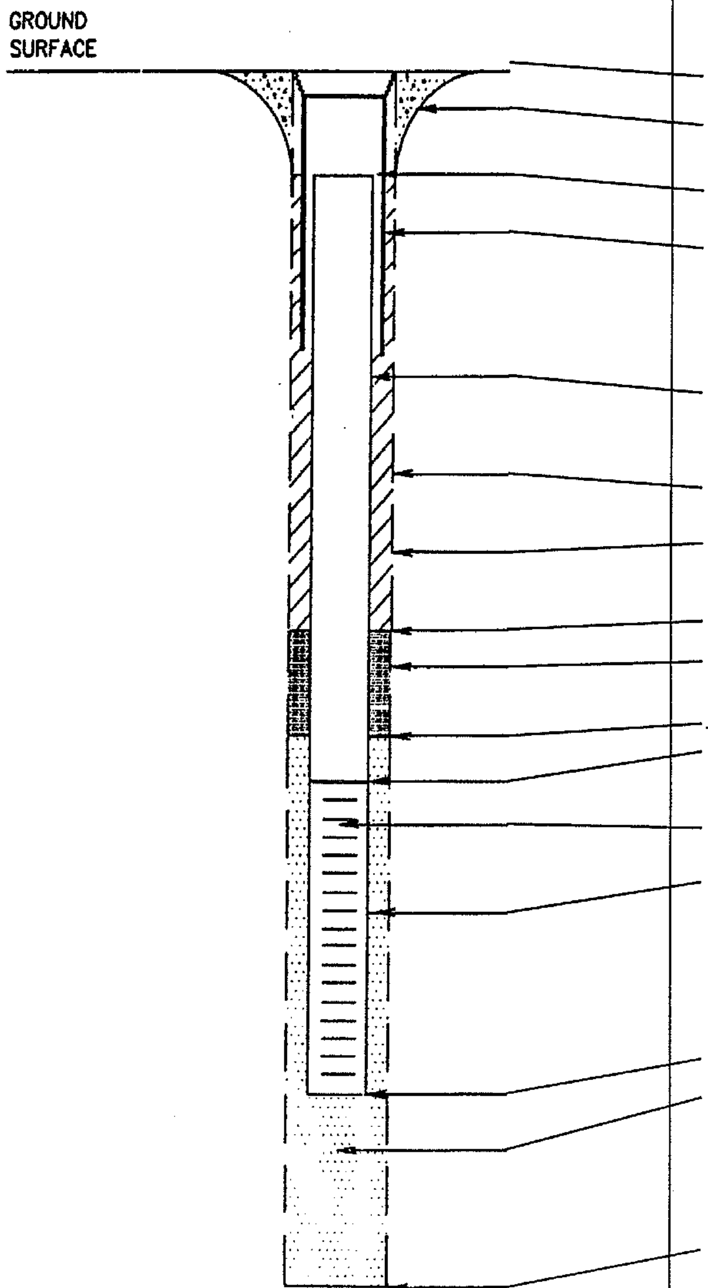
ELEVATION/DEPTH OF HOLE: 27 ft

NOT TO SCALE

UNCONSOLIDATED
MONITORING WELL CONSTRUCTION DIAGRAM

WELL NO. MW-61S

PROJECT: Bedford NWIRP – ERH Thermal Treatment, Site 4	DRILLER: Bowser-Morner, Inc.
PROJECT NO.: 2282.0892	DRILLING METHOD: Rotosonic Drilling
DATE: BORING NO.: MW-61S	DEVELOPMENT METHOD: Whale pump/surge block
ELEVATION:	
FIELD GEOLOGIST: Matthew Greenberg	



ELEVATION OF TOP OF SURFACE CASING:
TYPE OF SURFACE SEAL: Concrete
GROUND SURFACE ELEVATION:
ELEVATION OF TOP OF RISER:

I.D. OF SURFACE CASING: 8 in
TYPE OF SURFACE CASING: Steel flush Mount

RISER PIPE I.D. 2 in
TYPE OF RISER PIPE: Carbon steel

BOREHOLE DIAMETER: 6 in

TYPE OF BACKFILL: Cement-bentonite grout

ELEVATION/DEPTH TOP OF SEAL: 11 ft
TYPE OF SEAL: Medium size bentonite chips

ELEVATION/DEPTH TOP OF SAND PACK: 13 ft
ELEVATION/DEPTH TOP OF SCREEN: 15 ft

TYPE OF SCREEN: Stainless steel
SLOT SIZE X LENGTH: .020 in X 10 ft
TYPE OF SAND PACK: #5 Quartz sand

ELEVATION/DEPTH BOTTOM OF SCREEN: 25 ft

ELEVATION/DEPTH BOTTOM OF SAND PACK: 26 ft
TYPE OF BACKFILL BELOW OBSERVATION WELL: #5 Quartz sand

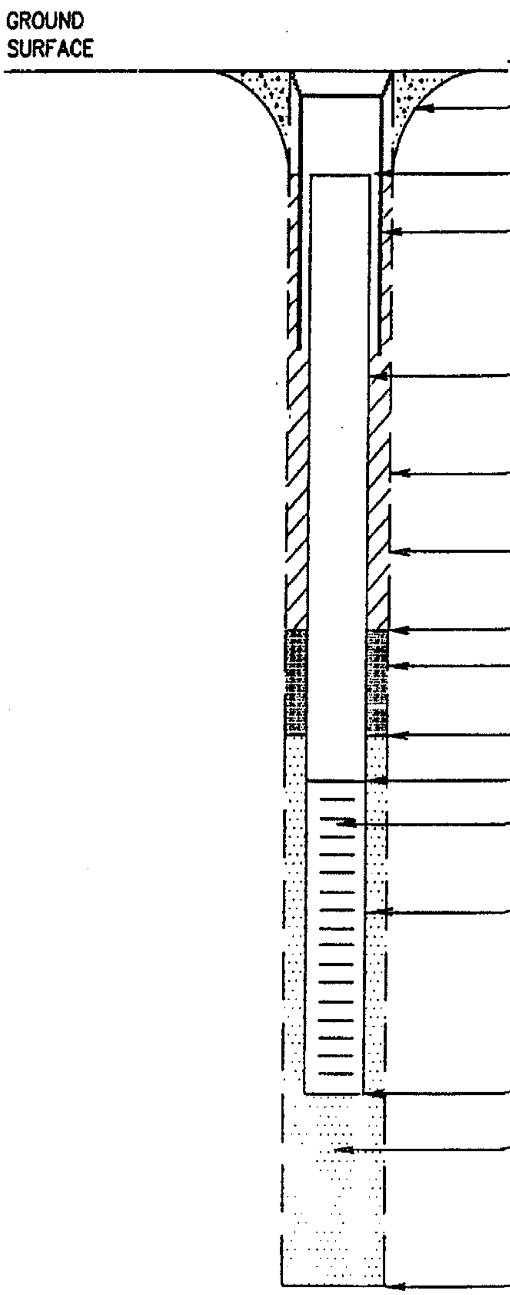
ELEVATION/DEPTH OF HOLE: 26 ft

NOT TO SCALE

UNCONSOLIDATED
MONITORING WELL CONSTRUCTION DIAGRAM

WELL NO. MW-62S

PROJECT: Bedford NWIRP – ERH Thermal Treatment, Site 4	DRILLER: Bowser-Morner, Inc.
PROJECT NO.: 2282.0892	DRILLING METHOD: Rotosonic Drilling
DATE:	BORING NO.: MW-62S
ELEVATION:	DEVELOPMENT METHOD: Whale pump/surge block
FIELD GEOLOGIST: Matthew Greenberg	



ELEVATION OF TOP OF SURFACE CASING: _____

TYPE OF SURFACE SEAL: Concrete

GROUND SURFACE ELEVATION: _____

ELEVATION OF TOP OF RISER: _____

I.D. OF SURFACE CASING: 8 in

TYPE OF SURFACE CASING: Steel flush Mount

RISER PIPE I.D. 2 in

TYPE OF RISER PIPE: Carbon steel

BOREHOLE DIAMETER: 6 in

TYPE OF BACKFILL: Cement-bentonite grout

ELEVATION/DEPTH TOP OF SEAL: 12 ft

TYPE OF SEAL: Medium size bentonite chips

ELEVATION/DEPTH TOP OF SAND PACK: 14 ft

ELEVATION/DEPTH TOP OF SCREEN: 16 ft

TYPE OF SCREEN: Stainless steel

SLOT SIZE X LENGTH: .020 in X 10 ft

TYPE OF SAND PACK: #5 Quartz sand

ELEVATION/DEPTH BOTTOM OF SCREEN: 26 ft

ELEVATION/DEPTH BOTTOM OF SAND PACK: 27 ft

TYPE OF BACKFILL BELOW OBSERVATION WELL: #5 Quartz sand

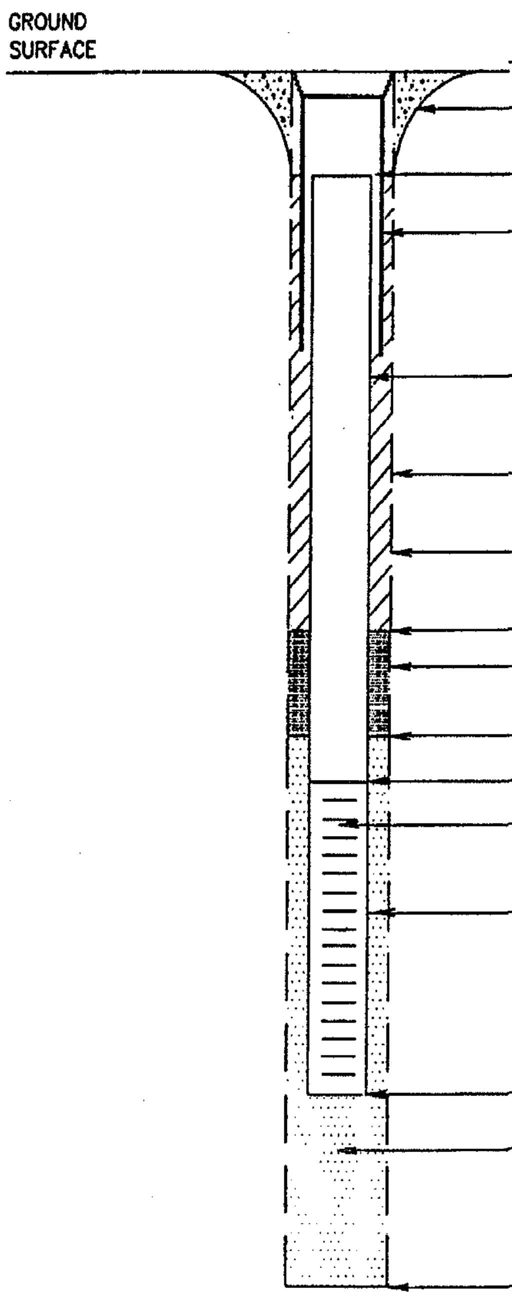
ELEVATION/DEPTH OF HOLE: 27 ft

NOT TO SCALE

UNCONSOLIDATED
MONITORING WELL
CONSTRUCTION DIAGRAM

WELL NO. MW-63S

PROJECT: Bedford NWIRP – ERH Thermal Treatment, Site 4	DRILLER: Bowser-Morner, Inc.
PROJECT NO.: 2282.0892	DRILLING METHOD: Rotosonic Drilling
DATE:	BORING NO.: MW-63S
ELEVATION:	DEVELOPMENT METHOD: Whale pump/surge block
FIELD GEOLOGIST: Matthew Greenberg	



NOT TO SCALE

ELEVATION OF TOP OF SURFACE CASING:
TYPE OF SURFACE SEAL: Concrete
GROUND SURFACE ELEVATION:
ELEVATION OF TOP OF RISER:

I.D. OF SURFACE CASING: 8 in
TYPE OF SURFACE CASING: Steel flush Mount

RISER PIPE I.D. 2 in
TYPE OF RISER PIPE: Carbon steel

BOREHOLE DIAMETER: 6 in

TYPE OF BACKFILL: Cement-bentonite grout

ELEVATION/DEPTH TOP OF SEAL: 10 ft
TYPE OF SEAL: Medium size bentonite chips

ELEVATION/DEPTH TOP OF SAND PACK: 12 ft
ELEVATION/DEPTH TOP OF SCREEN: 14 ft

TYPE OF SCREEN: Stainless steel
SLOT SIZE X LENGTH: .020 in X 10 ft
TYPE OF SAND PACK: #5 Quartz sand

ELEVATION/DEPTH BOTTOM OF SCREEN: 24 ft
ELEVATION/DEPTH BOTTOM OF SAND PACK: 25 ft
TYPE OF BACKFILL BELOW OBSERVATION WELL: #5 Quartz sand

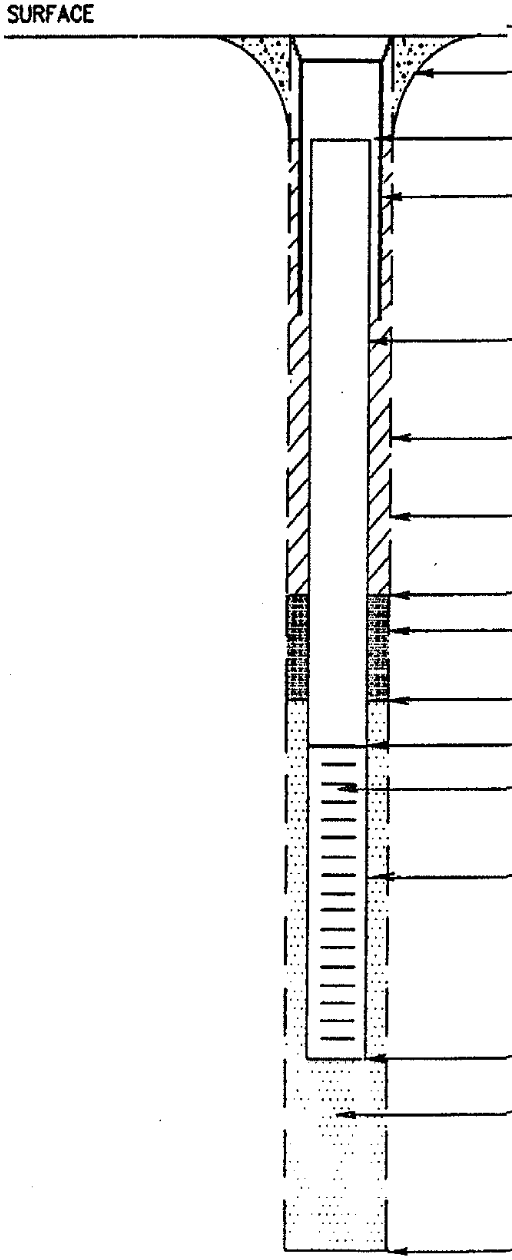
ELEVATION/DEPTH OF HOLE: 25 ft

UNCONSOLIDATED
MONITORING WELL
CONSTRUCTION DIAGRAM

WELL NO. MW-64S

PROJECT Bedford NWIRP – ERH Thermal Treatment, Site 4
PROJECT NO. 2282.0892
DATE
BORING NO.: MW-64S
ELEVATION
FIELD
GEOLOGIST Matthew Greenberg

DRILLER Bowser-Morner, Inc.
DRILLING
METHOD Rotosonic Drilling
DEVELOPMENT
METHOD Whale pump/surge block



ELEVATION OF TOP OF SURFACE CASING:
TYPE OF SURFACE SEAL: Concrete
GROUND SURFACE ELEVATION:
ELEVATION OF TOP OF RISER:

I.D. OF SURFACE CASING: 8 in
TYPE OF SURFACE CASING: Steel flush Mount

RISER PIPE I.D. 2 in
TYPE OF RISER PIPE: Carbon steel

BOREHOLE DIAMETER: 6 in

TYPE OF BACKFILL: Cement-bentonite grout

ELEVATION/DEPTH TOP OF SEAL: 10 ft
TYPE OF SEAL: Medium size bentonite chips

ELEVATION/DEPTH TOP OF SAND PACK: 12 ft
ELEVATION/DEPTH TOP OF SCREEN: 14 ft

TYPE OF SCREEN: Stainless steel
SLOT SIZE X LENGTH: .020 in X 10 ft
TYPE OF SAND PACK: #5 Quartz sand

ELEVATION/DEPTH BOTTOM OF SCREEN: 24 ft

ELEVATION/DEPTH BOTTOM OF SAND PACK: 25 ft
TYPE OF BACKFILL BELOW OBSERVATION WELL: #5 Quartz sand

ELEVATION/DEPTH OF HOLE: 25 ft

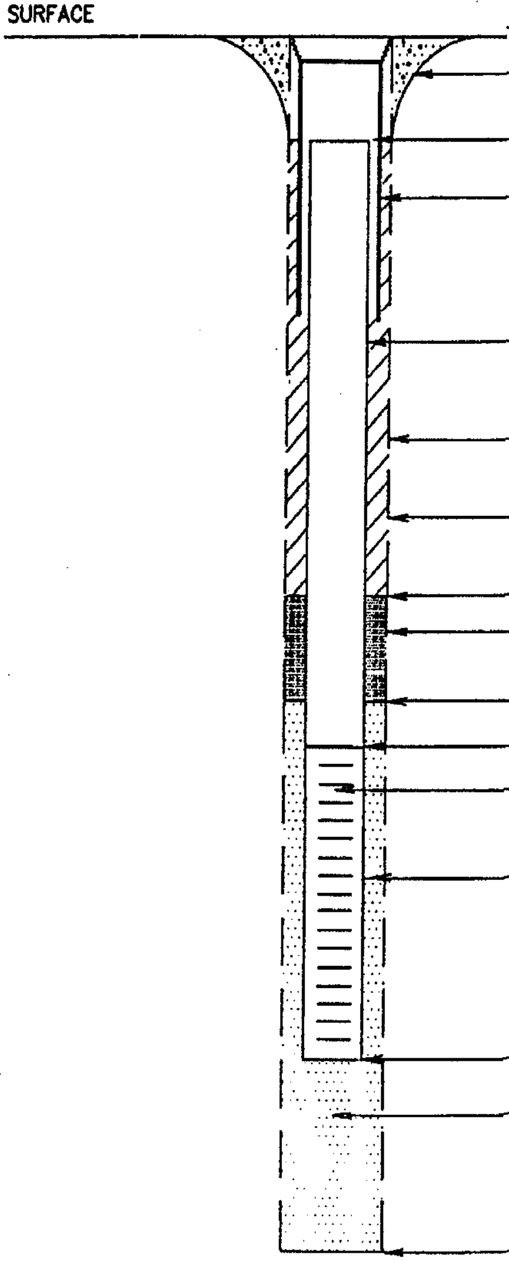
NOT TO SCALE

UNCONSOLIDATED
MONITORING WELL
CONSTRUCTION DIAGRAM

WELL NO. MW-65S

PROJECT: Bedford NWIRP – ERH Thermal Treatment, Site 4	DRILLER: Bowser-Morner, Inc.
PROJECT NO.: 2282.0892	DRILLING METHOD: Rotosonic Drilling
DATE:	BORING NO.: MW-65S
ELEVATION:	DEVELOPMENT METHOD: Whale pump/surge block
FIELD GEOLOGIST: Matthew Greenberg	

GROUND SURFACE



NOT TO SCALE

ELEVATION OF TOP OF SURFACE CASING:
TYPE OF SURFACE SEAL: Concrete
GROUND SURFACE ELEVATION:
ELEVATION OF TOP OF RISER:

I.D. OF SURFACE CASING: 8 in
TYPE OF SURFACE CASING: Steel flush Mount

RISER PIPE I.D. 2 in
TYPE OF RISER PIPE: Carbon steel

BOREHOLE DIAMETER: 6 in

TYPE OF BACKFILL: Cement-bentonite grout

ELEVATION/DEPTH TOP OF SEAL: 9 ft
TYPE OF SEAL: Medium size bentonite chips

ELEVATION/DEPTH TOP OF SAND PACK: 11 ft
ELEVATION/DEPTH TOP OF SCREEN: 13 ft

TYPE OF SCREEN: Stainless steel
SLOT SIZE X LENGTH: .020 in X 10 ft
TYPE OF SAND PACK: #5 Quartz sand

ELEVATION/DEPTH BOTTOM OF SCREEN: 23 ft

ELEVATION/DEPTH BOTTOM OF SAND PACK: 24 ft
TYPE OF BACKFILL BELOW OBSERVATION WELL: None

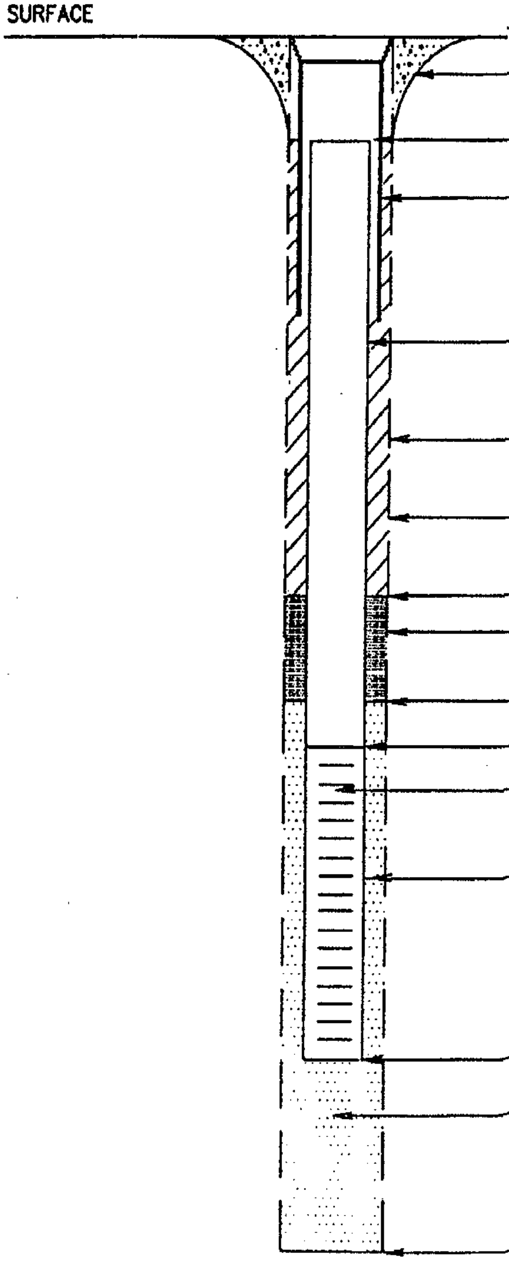
ELEVATION/DEPTH OF HOLE: 24 ft

UNCONSOLIDATED
MONITORING WELL CONSTRUCTION DIAGRAM

WELL NO. MW-66S

PROJECT	Bedford NWIRP – ERH Thermal Treatment, Site 4	DRILLER	Bowser-Morner, Inc.
PROJECT NO.	2282.0892	DRILLING METHOD	Rotosonic Drilling
DATE		BORING NO.: MW-66S	
ELEVATION		DEVELOPMENT METHOD	Whale pump/surge block
FIELD GEOLOGIST	Matthew Greenberg		

GROUND SURFACE



ELEVATION OF TOP OF SURFACE CASING: ______
TYPE OF SURFACE SEAL: Concrete
GROUND SURFACE ELEVATION: ______
ELEVATION OF TOP OF RISER: ______

I.D. OF SURFACE CASING: 8 in
TYPE OF SURFACE CASING: Steel flush Mount

RISER PIPE I.D. 2 in
TYPE OF RISER PIPE: Carbon steel

BOREHOLE DIAMETER: 6 in

TYPE OF BACKFILL: Cement-bentonite grout

ELEVATION/DEPTH TOP OF SEAL: 5 ft
TYPE OF SEAL: Medium size bentonite chips

ELEVATION/DEPTH TOP OF SAND PACK: 7 ft
ELEVATION/DEPTH TOP OF SCREEN: 9 ft

TYPE OF SCREEN: Stainless steel
SLOT SIZE X LENGTH: .020 in X 10 ft
TYPE OF SAND PACK: #5 Quartz sand

ELEVATION/DEPTH BOTTOM OF SCREEN: 19 ft

ELEVATION/DEPTH BOTTOM OF SAND PACK: 19 ft
TYPE OF BACKFILL BELOW OBSERVATION WELL: None

ELEVATION/DEPTH OF HOLE: 19 ft

NOT TO SCALE

APPENDIX D

Groundwater Sample Collection Record

ENSR

Well ID: MW-18SR

Ground Water Sample Collection Record

Client: Navy (Foster Wheeler) Date: 6-2-03 Time: Start 1440 (24hr)
Project No: ~~5060-068~~ 02840-006-300 Finish 1645
Site Location: NWIRP Bedford - Site 4
Weather Conds: Sunny, windy, 70's Collector(s): M. Greenberg, L. Burdick

1. WATER LEVEL DATA: (measured from Top of Casing)

Total well length:	27.35	Screen interval:	18-28	Total tubing length:	23 (ft)
Water table depth:	15.91	Casing type\diameter:	steel/2"	Tubing internal diam.:	0.375 (inches)
Water column length:		Pump intake depth:	23'	Minimum purge volume:	(liters)

(calculations on reverse)

2. WELL PURGE DATA

Purge Method: Peristaltic pump & dedicated tubing (teflon)

Acceptance Criteria (EPA Region I low flow groundwater sampling procedure)

- Temperature	3%	- ORP	+ or - 10 mV
- pH	+ or - 0.1	- Drawdown	< 0.3 ft
- D.O.	10% (0.5 mg/L if <1)	- Turbidity	< within 10%
- Spec. Cond.	3%		

Field Testing Equipment used:	Make	Model	Serial number
	YSI	610DM	02B0485AD
	YSI	6820 or 6920	99B1777AA
	LaMotte	2020 Turbidimeter	3592-3502
	Photovac	2020 PID	

Time (24hr)	Volume Removed (liters)	Temp. (°C)	pH	Spec. Cond. (uS/cm)	ORP (mV)	DO (mg/L)	Turbidity (NTU)	Flow Rate (ml/min)	Drawdown (feet)	Comments
1501	0.00	14.05	6.31	283	-140.2	1.93	37	250	0.13	Flow cell full
1511	0.25	13.20	6.14	298	-144.7	0.79	37	150	0.24	clear, odor
1516	0.50	13.23	6.18	350	-148.9	0.64	18	180	0.29	" "
1521	0.75	13.38	6.26	424	-154.7	0.52	12	180	0.30	" "
1526	1.00	13.24	6.26	424	-155.6	0.49	13	150	0.30	" "
1531	1.25	13.40	6.27	434	-156.5	0.50	11	150	0.28	" "
1536	1.50	13.40	6.28	416	-156.2	0.51	12	170	0.30	" "
1541	1.75	13.57	6.28	421	-155.5	0.49	11	170	0.30	" "
1546	2.00	13.43	6.29	431	-154.5	0.48	9.7	150	0.30	" "
1551	2.25	13.56	6.29	429	-152.0	0.47	8.7	150	0.30	" "
1556	2.50	13.52	6.28	431	-150.0	0.48	6.0	150	0.30	" "
ready to sample										
sample time 1645										

(continued on back)

Sample Collector(s): L. Burdick Date: 06/02/03

Well ID: MW-18SR

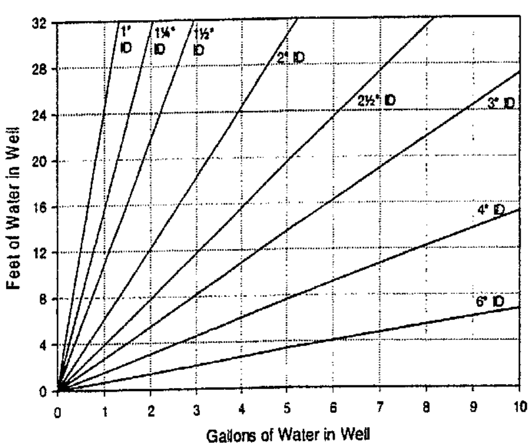
(continued from front)

Time (24hr)	Volume Removed (literss)	Temp. (°C)	pH	Spec. Cond. (µS/cm)	ORP (mV)	DO (mg/L)	Turbidity (NTU)	Flow Rate (ml/min)	Drawdown (feet)	Comments

L Burdick

SAMPLE COLLECTION DATA

Sample ID	No. of Containers	Container Type	Preservation	Analysis	Time (24 hr)
MW-18SR-GW-060203	3	40 ml	HCL	TCL VOCs	1605
"	2	1 L	4°C	2-Methlnapthalene	1605
MW-18SR	1	500ml plastic	4°C	test kit	1605



Calculations:

tubing length	=	3	(add 3ft for pump)
	x	0.0217	Liters per foot
tubing vol.	=	0.065	
	+	0.25	(flow cell vol., L)
system vol.	=	$\boxed{0.315}$	(liters)

Volume per linear ft of tubing		
ID (in)	Gallon	Liter
0.250	0.0025	0.0097
0.375	0.0057	0.0217
0.500	0.0102	0.0386
0.750	0.0229	0.0869
1.000	0.0408	0.1544
1.250	0.0637	0.2413
1.500	0.0918	0.3475
2.000	0.1632	0.6178
2.500	0.2550	0.9653
3.000	0.3672	1.3900
4.000	0.6528	2.4711
6.000	1.4688	5.5600

Comments: A flow rate around 180 ml/min is appropriate
PID reading of purge water = ppm

Collector(s): Lori Burdick   Date: 06/02/03

ENSR

Well ID: ~~MW-135~~ (MG) MW-42SR

Ground Water Sample Collection Record

Client: Navy (Foster Wheeler)	Date: 6-2-03	Time: Start 1508 (24hr)	
Project No: ~~5060-068~~ 02840-006-300		Finish 1602	
Site Location: NWIRP Bedford - Site 4			
Weather Conds: Sunny, high 60's.	Collector(s): M. Greenberg, L. Burdick		

1. WATER LEVEL DATA: (measured from Top of Casing)

Total well length:	24.57' TIC	Screen interval:	15-25' bgs	Total tubing length:	22 (ft)
Water table depth:	14.93' TIC	Casing type\diameter:	Steel / 2"	Tubing internal diam.:	0.375 (inches)
Water column length:		Pump intake depth:	20' bgs	Minimum purge volume:	(liters)

(calculations on reverse)

2. WELL PURGE DATA

Purge Method: Peristaltic pump & dedicated tubing (teflon)

Acceptance Criteria (EPA Region I low flow groundwater sampling procedure)

- Temperature	3%	- ORP	+ or - 10 mV
- pH	+ or - 0.1 u	- Drawdown	< 0.3 ft
- D.O.	10% (0.5 mg/L if <1)	- Turbidity	< within 10%
- Spec. Cond.	3%		

Field Testing Equipment used:	Make	Model	Serial number
	YSI	610DM	
	YSI	6820 or 6920	02F0329 AJ
	LaMotte	2020 Turbidimeter	0639-1298
	Photovac	2020 PID	

Time (24hr)	Volume Removed ~~(liters)~~ gal	Temp. (°C)	pH	Spec. Cond. (µS/cm)	ORP (mV)	DO (mg/L)	Turbidity (NTU)	Flow Rate (ml/min)	Drawdown (feet)	Comments
1511	0.00	14.50	7.52	107	-9.0	0.01	45	150	15.17	Flow cell full
1521	0.5	14.33	6.78	109	3.8	1.54	38	170	15.59	
1526	0.8	14.33	6.77	105	5.9	1.76	45	170	15.67	
1531	1.0	14.18	6.69	112	6.9	1.60	40	130	15.57	
1536	1.4	14.27	6.71	111	6.4	1.56	50	175	15.77	
1541	1.6	14.32	6.75	106	3.8	1.62	55	150	15.79	
1546	1.8	14.47	6.64	119	0.4	1.49	50	160	15.81	
1551	2.0	14.48	6.66	115	-3.2	1.57	55	160	15.84	
1556	2.2	14.41	6.60	121	-7.0	1.50	45	160	15.85	
1602	End purge of well. Purge total of ~2.5 gals.									

(continued on back)

Sample Collector(s): M. Greenberg Date: 6-2-03

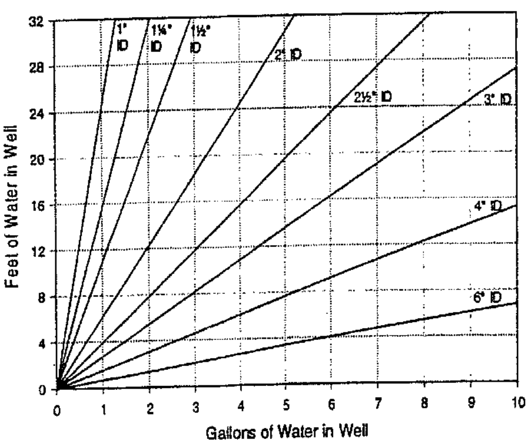
Well ID: MW-42SR

(continued from front)

Time (24hr)	Volume Removed (literss)	Temp. (°C)	pH	Spec. Cond. (µS/cm)	ORP (mV)	DO (mg/L)	Turbidity (NTU)	Flow Rate (ml/min)	Drawdown (feet)	Comments

SAMPLE COLLECTION DATA

Sample ID	No. of Containers	Container Type	Preservation	Analysis	Time (24 hr)
MW-42SR-GW-060203	3	40 ml	HCL	TCL VOCs	1625
MW-42SR-GW-060203	2	1L	4°C	2-Methlnapthalene	1625
MW-42SR	1	500mL plastic	4°C	test kits	1625



Calculations:

tubing length	=	3	(add 3ft for pump)
	x	0.0217	Liters per foot
tubing vol.	=	0.065	
	+	0.25	(flow cell vol., L)
system vol.	=	0.315	(liters)

Volume per linear ft of tubing		
ID (in)	Gallon	Liter
0.250	0.0025	0.0097
0.375	0.0057	0.0217
0.500	0.0102	0.0386
0.750	0.0229	0.0869
1.000	0.0408	0.1544
1.250	0.0637	0.2413
1.500	0.0918	0.3475
2.000	0.1632	0.6178
2.500	0.2550	0.9653
3.000	0.3672	1.3900
4.000	0.6528	2.4711
6.000	1.4688	5.5600

Comments: A flow rate around 180 ml/min is appropriate
PID reading of purge water = ppm

Collector(s): ____________________ Date: ____________________

ENSR

Well ID: MW-608

Ground Water Sample Collection Record

Client: Navy (Foster Wheeler)	Date: 5/29/03	Time: Start 1310	(24hr)
Project No: ~~5060-068~~ 02840-006-300		Finish 1515	
Site Location: NWIRP Bedford - Site 4			
Weather Conds: windy, high 60's, sunny	Collector(s): L. Burdick		

1. WATER LEVEL DATA: (measured from Top of Casing)

Total well length:	25.85	Screen interval:		Total tubing length:		(ft)
Water table depth:	20.30	Casing type\diameter:	steel/2"	Tubing internal diam.:	0.375	(inches)
Water column length:	5.55	Pump intake depth:		Minimum purge volume:		(liters)

(calculations on reverse)

2. WELL PURGE DATA

Purge Method: Peristaltic pump & dedicated tubing (teflon)

Acceptance Criteria (EPA Region I low flow groundwater sampling procedure)

- Temperature	3%	- ORP	+ or - 10 mV
- pH	+ or - 0.1 u	- Drawdown	< 0.3 ft
- D.O.	10% (0.5 mg/L if <1)	- Turbidity	< within 10%
- Spec. Cond.	3%		

Field Testing Equipment used:	Make	Model	Serial number
	YSI	610DM	02F0329 AT
	YSI	6820 or 6920	96D49277
	LaMotte	2020 Turbidimeter	3592-3502
	Photovac	2020 PID	

Time (24hr)	Volume Removed (liters)	Temp. (°C)	pH	Spec. Cond. (uS/cm)	ORP (mV)	DO (mg/L)	Turbidity (NTU)	Flow Rate (ml/min)	Drawdown (feet)	Comments
1315	0.00	14.44	6.41	916	-93.3	1.40	10	250	0.03	Flow cell full clear, odor
1325	0.25	13.34	6.25	848	-125.7	0.04	36	225	0.50	cloudy, odor
1335	0.50	13.42	6.23	821	-121.5	0.52	21	180	0.80	" "
1340	[illegible]	13.56	6.26	832	-130.4	0.47	15	200	0.95	clear, odor
1345	1.25	13.57	6.26	824	-132.1	0.44	10	150	1.08	0.8 background, spike 1.1 on PID
1350	1.50	13.37	6.23	801	-126.5	0.40	5.6	150	1.16	1.3 - PID odor
1355	1.75	13.12	6.22	790	-125.9	0.38	5.5	150	1.28	clear - odor
1400	2.00	13.41	6.20	779	-124.9	0.35	5.4	150	1.44	clear - odor
1405	2.25	13.10	6.21	783	-127.2	0.37	4.8	150	1.54	" "
1410	ready	to	sample							

(continued on back)

Sample Collector(s): Lori B Burdick Date: 5/29/03

Well ID: MW-60S

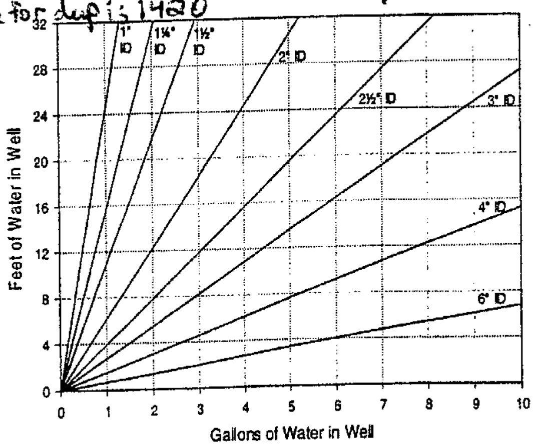
(continued from front)

Time (24hr)	Volume Removed (literss)	Temp. (°C)	pH	Spec. Cond. (µS/cm)	ORP (mV)	DO (mg/L)	Turbidity (NTU)	Flow Rate (ml/min)	Drawdown (feet)	Comments

SAMPLE COLLECTION DATA

Sample ID	No. of Containers	Container Type	Preservation	Analysis	Time (24 hr)
MW-62S-GW-052903	~~3~~ 6	40 ml	HCL	TCL VOCs	1415
MW-62S-GW-052903	~~2~~ 4	1L	4°C	2-Methlnapthalene	1415
	1	500ml plastic	4°C	test kits	1415

Dup labeled as MW-62S-GW-0529030 → # of containers is for sample & dup
Time for dup is 1420



Calculations:

tubing length = 3 (add 3ft for pump)
x 0.0217 Liters per foot
tubing vol. = 0.065
\+ 0.25 (flow cell vol., L)
system vol. = $\boxed{0.315}$ (liters)

Volume per linear ft of tubing		
ID (in)	Gallon	Liter
0.250	0.0025	0.0097
0.375	0.0057	0.0217
0.500	0.0102	0.0386
0.750	0.0229	0.0869
1.000	0.0408	0.1544
1.250	0.0637	0.2413
1.500	0.0918	0.3475
2.000	0.1632	0.6178
2.500	0.2550	0.9653
3.000	0.3672	1.3900
4.000	0.6528	2.4711
6.000	1.4688	5.5600

Comments: A flow rate around 180 ml/min is appropriate
PID reading of purge water = ppm

Collector(s): Lori Brudick Date: 5/29/03

ENSR

Well ID: MW-61S

Page 1 of 2

Ground Water Sample Collection Record

Client: Navy (Foster Wheeler)	Date: 5-30-03	Time: Start 0853 (24hr)	
Project No: ~~5060-068~~ 02840-006-300		Finish 0955	
Site Location: NWIRP Bedford - Site 4			
Weather Conds: overcast, mid 60s	Collector(s): M. Greenberg, L. Burdick		

1. **WATER LEVEL DATA: (measured from Top of Casing)**

Total well length: 24.45' TIC Screen interval: 15-25' BGS Total tubing length: 24 (ft)

Water table depth: 17.49' TIC Casing type\diameter: steel/2" Tubing internal diam.: 0.375 (inches)

Water column length: ______ Pump intake depth: ~~21.3ft~~ (MG) 21.5 ft bgs Minimum purge volume: ______ (liters)

(calculations on reverse)

2. **WELL PURGE DATA**

Purge Method: Peristaltic pump & dedicated tubing (teflon)

Acceptance Criteria (EPA Region I low flow groundwater sampling procedure)

- Temperature	3%	- ORP	+ or - 10 mV
- pH	+ or - 0.1 u	- Drawdown	< 0.3 ft
- D.O.	10% (0.5 mg/L if <1)	- Turbidity	< within 10%
- Spec. Cond.	3%		

Field Testing Equipment used:	Make	Model	Serial number
	YSI	610DM	
	YSI	6820 or 6920	
	LaMotte	2020 Turbidimeter	
	Photovac	2020 PID	

Time (24hr)	Volume Removed (liters)	Temp. (°C)	pH	Spec. Cond. (µS/cm)	ORP (mV)	DO (mg/L)	Turbidity (NTU)	Flow Rate (ml/min)	Drawdown (feet)	Comments
0855	0.00	12.93	6.23	600	177.1	3.53	~~17.79~~	250	17.79	Flow cell full PID: 2.3 ppm. (MG)
							65 (MG)			
0905	3	12.71	6.00	452	185.1	2.03	40	120	18.03	
0910	3.5	12.68	5.96	441	183.6	2.13	36	120	18.11	PID=1.6 ppm
0915		12.69	5.93	437	173.7	3.50	38	130	18.17	
0920	6	12.70	5.93	437	163.6	3.83	28	150	18.23	
0925	8	12.54	5.93	438	141.1	3.20	23	150	18.30	
0930		12.61	5.94	437	123.5	3.23	27	150	18.34	
0935	10	12.69	5.94	440	109.3	2.90	21	160	18.39	
0940	12	12.64	5.93	439	103.4	2.58	17	150	18.44	
0945		12.75	5.93	440	97.0	2.66	16	150	18.48	
0950	15	12.83	5.93	443	91.7	2.44	14	150	18.50	
0955	Shut down purge. Wait for recharge. Purge total of ~2.5 gals.									

(continued on back)

Sample Collector(s): M. Greenberg Date: 5-30-03

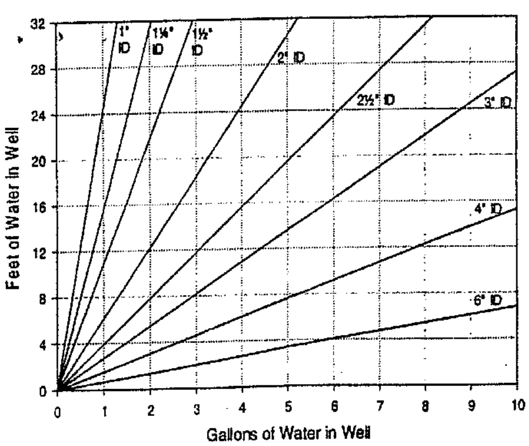
Well ID: MW-615

(continued from front)

Time (24hr)	Volume Removed (literss)	Temp. (°C)	pH	Spec. Cond. (µS/cm)	ORP (mV)	DO (mg/L)	Turbidity (NTU)	Flow Rate (ml/min)	Drawdown (feet)	Comments

SAMPLE COLLECTION DATA

Sample ID	No. of Containers	Container Type	Preservation	Analysis	Time (24 hr)
MW-615-GW-053003	3	40 ml	HCL	TCL VOCs	1025
MW-615-GW-053003	2	1L	4°C	2-Methlnapthalene	1025
MW-615	1	500 mL plastic	4°C	test kits	1025



Calculations:

tubing length	=	3	(add 3ft for pump)
	x	0.0217	Liters per foot
tubing vol.	=	0.065	
	+	0.25	(flow cell vol., L)
system vol.	=	0.315	(liters)

Volume per linear ft of tubing		
ID (in)	Gallon	Liter
0.250	0.0025	0.0097
0.375	0.0057	0.0217
0.500	0.0102	0.0386
0.750	0.0229	0.0869
1.000	0.0408	0.1544
1.250	0.0637	0.2413
1.500	0.0918	0.3475
2.000	0.1632	0.6178
2.500	0.2550	0.9653
3.000	0.3672	1.3900
4.000	0.6528	2.4711
6.000	1.4688	5.5600

Comments: A flow rate around 180 ml/min is appropriate
PID reading of purge water = ppm

Collector(s): M. Greenberg Date: 5-30-03

ENSR

Well ID: MW-625

Ground Water Sample Collection Record

Client: Navy (Foster Wheeler)	Date: 5-29-03	Time: Start 1312 (24hr)	
Project No: ~~5060-068~~ 02840-006-300		Finish 1441	
Site Location: NWIRP Bedford - Site 4			
Weather Conds: Sunny, high 60s	Collector(s): M. Greenberg, L. Burdick		

1. WATER LEVEL DATA: (measured from Top of Casing)

Total well length:	25.55' TIC	Screen interval:	16-26'	Total tubing length:	24 (ft)
Water table depth:	12.79' TIC	Casing type\diameter:	Steel / 2"	Tubing internal diam.:	0.375 (inches)
Water column length:		Pump intake depth:	22 ft bgs	Minimum purge volume:	(liters)

(calculations on reverse)

2. WELL PURGE DATA

Purge Method: Peristaltic pump & dedicated tubing (teflon)

Acceptance Criteria (EPA Region I low flow groundwater sampling procedure)

- Temperature	3%	- ORP	+ or - 10 mV
- pH	+ or - 0.1 u	- Drawdown	< 0.3 ft
- D.O.	10% (0.5 mg/L if <1)	- Turbidity	< within 10%
- Spec. Cond.	3%		

Field Testing Equipment used:	Make	Model	Serial number
	YSI	610DM	
	YSI	6820 or 6920	
	LaMotte	2020 Turbidimeter	
	Photovac	2020 PID	

Time (24hr)	Volume Removed (liters)	Temp. (°C)	pH	Spec. Cond. (µS/cm)	ORP (mV)	DO (mg/L)	Turbidity (NTU)	Flow Rate (ml/min)	Drawdown (feet)	Comments
1314	0.00	13.67	6.57	252	82.4	3.69	50	200	17.92	Flow cell full
1324	2	12.56	5.96	176	91.7	2.93	4.5	170	18.61	
1330	~~2.3~~ MB	12.72	5.93	176	88.1	2.96	50	180	13.78	
1337	~~2.7~~ MC	12.78	5.94	177	72.1	2.94	27	190	19.08	PID = NAB
1344	~~3~~ MB	12.61	5.99	173	69.5	2.85	20	200	19.35	PID = NAB
1350	~~3.3~~ MC	12.35	6.07	171	53.6	2.68	13	200	19.47	
1355	6	12.57	6.03	175	28.6	2.49	9.1	180	19.62	
1404	8	12.29	6.01	187	16.7	2.05	11	200	19.84	
1412	11	12.32	6.15	200	7.1	1.81	9.5	160	19.87	
1418	12	12.37	6.21	226	0.8	1.61	6.9	150	19.87	
1423	15	12.23	6.24	249	-19.5	1.44	6.0	150	19.79	
1428	17	12.26	6.26	272	-30.5	1.36	3.7	170	19.91	
1433	20	12.22	6.26	277	-31.5	1.40	5.9	170	19.94	
1438	22	12.19	6.25	286	-30.1	1.45	5.4	170	19.95	
1441	End purge.	Total of ~			4 gals.	Allow	for recharge.			

(continued on back)

Sample Collector(s): M. Greenberg, L. Burdick Date: 5-29-03

Well ID: MW-62S

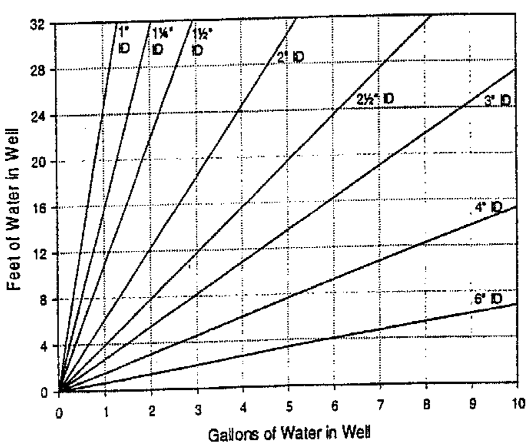
(continued from front)

Time (24hr)	Volume Removed (literss)	Temp. (°C)	pH	Spec. Cond. (uS/cm)	ORP (mV)	DO (mg/L)	Turbidity (NTU)	Flow Rate (ml/min)	Drawdown (feet)	Comments

SAMPLE COLLECTION DATA

Sample ID	No. of Containers	Container Type	Preservation	Analysis	Time (24 hr)
MW-62S-GW-052903	~~3~~ 9	40 ml	HCL	TCL VOCs	1600
MW-62S-GW-052903	~~2~~ 6	1L	4°C	2-Methlnapthalene	1600
	1	500mL plastic	4°C	test kits	1600

Collect MS/MSD as well (total of 9-40mL vials, 6-1L jars). 1600



Calculations:

tubing length	=	3	(add 3ft for pump)
	x	0.0217	Liters per foot
tubing vol.	=	0.065	
	+	0.25	(flow cell vol., L)
system vol.	=	$\boxed{0.315}$	(liters)

Volume per linear ft of tubing		
ID (in)	Gallon	Liter
0.250	0.0025	0.0097
0.375	0.0057	0.0217
0.500	0.0102	0.0386
0.750	0.0229	0.0869
1.000	0.0408	0.1544
1.250	0.0637	0.2413
1.500	0.0918	0.3475
2.000	0.1632	0.6178
2.500	0.2550	0.9653
3.000	0.3672	1.3900
4.000	0.6528	2.4711
6.000	1.4688	5.5600

Comments: A flow rate around 180 ml/min is appropriate
PID reading of purge water = 0 ppm

Collector(s): M. Greenberg, L. Burdick Date: 5-29-03

ENSR

Well ID: MW-63S

Ground Water Sample Collection Record

Client: Navy (Foster Wheeler)	Date: 6-2-03	Time: Start 1010	(24hr)
Project No: ~~5060-068~~ 02840-006-300		Finish 1136	
Site Location: NWIRP Bedford - Site 4			
Weather Conds: Sunny, 60s	Collector(s): M. Greenberg, L. Burdick		

1. WATER LEVEL DATA: (measured from Top of Casing)

Total well length:	24.13' TIC	Screen interval:	15-25' bgs	Total tubing length:	23	(ft)
Water table depth:	14.67' TIC	Casing type\diameter:	Steel / 2"	Tubing internal diam.:	0.375	(inches)
Water column length:		Pump intake depth:	20' bgs	Minimum purge volume:		(liters)

(calculations on reverse)

2. WELL PURGE DATA

Purge Method: Peristaltic pump & dedicated tubing (teflon)

Acceptance Criteria (EPA Region I low flow groundwater sampling procedure)

- Temperature	3%	- ORP	+ or - 10 mV
- pH	+ or - 0.1 u	- Drawdown	< 0.3 ft
- D.O.	10% (0.5 mg/L if <1)	- Turbidity	< within 10%
- Spec. Cond.	3%		

Field Testing Equipment used:	Make	Model	Serial number
	YSI	610DM	
	YSI	6820 or 6920	02F0329 AJ
	LaMotte	2020 Turbidimeter	0639-1248
	Photovac	2020 PID	

Time (24hr)	Volume Removed ~~(liters)~~ (gal)	Temp. (°C)	pH	Spec. Cond. (µS/cm)	ORP (mV)	DO (mg/L)	Turbidity (NTU)	Flow Rate (ml/min)	Drawdown (feet)	Comments
1013	0.00	13.25	6.04	267	122.1	1.25	26	180	14.83	Flow cell full
1023	0.5	12.42	5.96	166	50.0	1.57	300	190	15.06	
1028	0.7	12.53	6.01	180	20.0	1.75	550	140	15.11	
1033	1.0	12.67	6.05	192	2.0	1.69	800	150	15.12	
1038	1.1	12.73	6.09	228	-23.4	1.45	650	160	15.12	
1043	1.2	12.73	6.13	251	-39.5	1.25	550	170	~~15.19~~	15.19 MG
1048	1.3	12.77	6.14	264	-48.9	1.13	450	160	15.19	
1053	1.5	12.72	6.18	277	-58.1	1.03	300	170	15.23	
1058	1.8	12.74	6.16	287	-64.9	0.90	210	160	15.22	
1103	2.0	12.75	6.16	290	-69.3	0.85	180	160	15.23	
1108	2.3	12.85	6.17	292	-73.8	0.80	110	160	15.24	
1113	2.5	12.78	6.17	294	-77.6	0.73	70	160	15.24	
1118	2.7	12.81	6.16	292	-79.9	0.68	60	150	15.24	
1123	3.0	12.88	6.16	292	-81.9	0.67	39	170	15.25	
1128	3.2	12.82	6.16	291	-83.4	0.64	39	160	15.26	
1133	3.5	12.82	6.16	290	-84.5	0.65	32	170	15.28	
1136 End purge at H MG ~ 3.75 gals.										

(continued on back)

Sample Collector(s): M. Greenberg   Date: 6-2-03

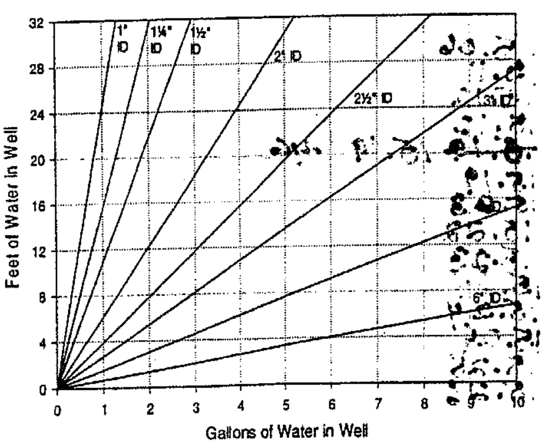
Well ID: MW-635

(continued from front)

Time (24hr)	Volume Removed (literss)	Temp. (°C)	pH	Spec. Cond. (µS/cm)	ORP (mV)	DO (mg/L)	Turbidity (NTU)	Flow Rate (ml/min)	Drawdown (feet)	Comments

SAMPLE COLLECTION DATA

Sample ID	No. of Containers	Container Type	Preservation	Analysis	Time (24 hr)
MW-635-GW-060203	3	40 ml	HCL	TCL VOCs	1205
MW-635-GW-060203	2	1L	4°C	2-Methlnapthalene	1205
MW-635	1	500mL plastic	4°C	test kits	1205



Calculations:

tubing length = 3 (add 3ft for pump)

x 0.0217 Liters per foot

tubing vol = 0.065

+ 0.25 (flow cell vol. L)

system vol = $\boxed{0.3[illegible]}$ (liters)

Volume per linear ft of tubing		
ID (in)	Gallon	Liter
0.250	0.0025	0.0097
0.375	0.0057	0.0217
0.500	0.0102	0.0386
0.750	0.0229	0.0869
1.000	0.0408	0.1544
1.250	0.0637	0.2413
1.500	0.0918	0.3475
2.000	0.1632	0.6178
2.500	0.2550	0.9653
3.000	0.3672	1.3900
4.000	0.6528	2.4711
6.000	1.4688	5.5600

Comments: A flow rate around 180 ml/min is appropriate
PID reading of purge water = ppm

Collector(s): M. Greenberg Date: 6-2-03

ENSR

Well ID: MW-64S

Ground Water Sample Collection Record

Client: Navy (Foster Wheeler) Date: 5-30-03 Time: Start 0855 (24hr)
Project No: ~~5060-068~~ 02840-006-300 Finish
Site Location: NWIRP Bedford - Site 4
Weather Conds: Overcast, mid 60s. Collector(s): M. Greenberg, L. Burdick

1. WATER LEVEL DATA: (measured from Top of Casing)

Total well length: 23.50' TIC Screen interval: 14-24' BGS Total tubing length: 25 (ft)
Water table depth: 14.78' TIC Casing type\diameter: Steel / 2" Tubing internal diam.: 0.375 (inches)
Water column length: ______ Pump intake depth: 19.5' bgs Minimum purge volume: ______ (liters)

(calculations on reverse)

2. WELL PURGE DATA

Purge Method: Peristaltic pump & dedicated tubing (teflon)

Acceptance Criteria (EPA Region I low flow groundwater sampling procedure)

- Temperature	3%	- ORP	+ or - 10 mV
- pH	+ or - 0.1 u	- Drawdown	< 0.3 ft
- D.O.	10% (0.5 mg/L if <1)	- Turbidity	< within 10%
- Spec. Cond.	3%		

Field Testing Equipment used:	Make	Model	Serial number
	YSI	610DM	02B0935AD
	YSI	6820 or 6920	99B137AA
	LaMotte	2020 Turbidimeter	3542-3502
	Photovac	2020 PID	

Time (24hr)	Volume Removed (liters)	Temp. (°C)	pH	Spec. Cond. (uS/cm)	ORP (mV)	DO (mg/L)	Turbidity (NTU)	Flow Rate (ml/min)	Drawdown (feet)	Comments
0902	0.00	12.42	6.05	412	54.2	2.56	2.1	200	0.05	Flow cell full PID 5.2 odor
0912	0.25	11.78	5.90	276	32.4	1.77	3.0	200	0.10	odor, clear
0917	0.50	11.63	5.92	278	25.4	2.06	1.8	200	0.11	PID 14.5, odor, clear
0922	0.75	11.54	5.94	278	22.4	2.03	2.1	240	0.12	odor, clear
0927	1.00	11.64	5.97	281	20.7	2.42	2.5	200	0.14	PID 6.0, odor, clear
0932	1.25	11.69	5.98	284	18.3	2.42	3.2	200	0.17	clear, odor
0937	1.50	11.73	5.99	286	16.2	3.02	3.5	200	0.18	PID 1.4, clear
0942	1.75	11.81	6.01	288	14.7	2.75	3.3	200	0.18	clear, some odor
0947	2.00	11.84	6.01	289	14.3	2.78	3.4	200	0.20	PID 0.8, clear
0952	2.25	11.94	6.03	295	13.4	2.77	2.8	200	0.20	clear
0957	2.50	12.06	6.04	297	13.6	2.92	2.9	200	0.21	clear
1002	3.00	12.64	6.04	296	14.0	2.69	3.1	200	0.22	clear
1005	ready	to	sample.							

(continued on back)

Sample Collector(s): Lori Burdick Date: 5/30/03

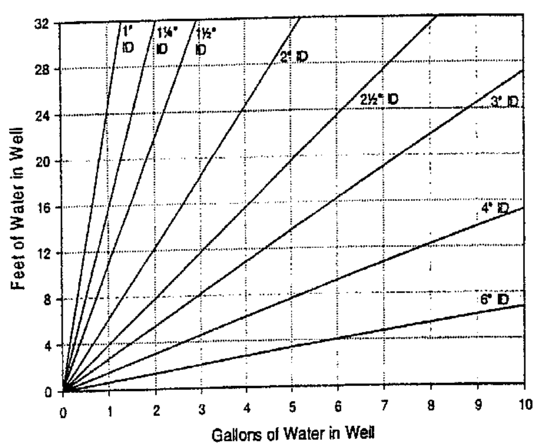
Well ID: MW-645

(continued from front)

Time (24hr)	Volume Removed (literss)	Temp. (°C)	pH	Spec. Cond. (µS/cm)	ORP (mV)	DO (mg/L)	Turbidity (NTU)	Flow Rate (ml/min)	Drawdown (feet)	Comments

SAMPLE COLLECTION DATA

Sample ID	No. of Containers	Container Type	Preservation	Analysis	Time (24 hr)
MW-645-GW-053003	3	40 ml	HCL	TCL VOCs	1005
MW-645-GW-053003	2	1 L	4°C	2-Methlnapthalene	1005
MW-645	1	500 ml plastic	4°C	test kits	1005



Calculations:

tubing length = 3 (add 3ft for pump)

x 0.0217 Liters per foot

tubing vol. = 0.065

\+ 0.25 (flow cell vol., L)

system vol. = 0.315 (liters)

Volume per linear ft of tubing		
ID (in)	Gallon	Liter
0.250	0.0025	0.0097
0.375	0.0057	0.0217
0.500	0.0102	0.0386
0.750	0.0229	0.0869
1.000	0.0408	0.1544
1.250	0.0637	0.2413
1.500	0.0918	0.3475
2.000	0.1632	0.6178
2.500	0.2550	0.9653
3.000	0.3672	1.3900
4.000	0.6528	2.4711
6.000	1.4688	5.5600

Comments: A flow rate around 180 ml/min is appropriate
PID reading of purge water = ppm

Collector(s): [signature] Date: 5/30/03

ENSR

Well ID: MW-65S

Ground Water Sample Collection Record

Client: Navy (Foster Wheeler)	Date: 6-2-03	Time: Start 1024 (24hr)	
Project No: ~~5060-068~~ 02840-006-300		Finish	
Site Location: NWIRP Bedford - Site 4			
Weather Conds: Sunny, windy, 60's	Collector(s): M. Greenberg L. Burdick		

1. WATER LEVEL DATA: (measured from Top of Casing)

Total well length: 22.61' TIC	Screen interval: 13-23' bgs	Total tubing length:	20 (ft)
Water table depth: 10.62' TIC	Casing type\diameter: Steel / 2"	Tubing internal diam.:	0.375 (inches)
Water column length:	Pump intake depth: 17' bgs	Minimum purge volume:	(liters)

(calculations on reverse)

2. WELL PURGE DATA

Purge Method: Peristaltic pump & dedicated tubing (teflon)

Acceptance Criteria (EPA Region I low flow groundwater sampling procedure)

- Temperature	3%	- ORP	+ or - 10 mV
- pH	+ or - 0.1 ι	- Drawdown	< 0.3 ft
- D.O.	10% (0.5 mg/L if <1)	- Turbidity	< within 10%
- Spec. Cond.	3%		

Field Testing Equipment used:	Make	Model	Serial number
	YSI	610DM	02B0485AD
	YSI	6820 or 6920	99B1377AA
	LaMotte	2020 Turbidimeter	3542-3502
	Photovac	2020 PID	

Time (24hr)	Volume Removed (liters)	Temp. (°C)	pH	Spec. Cond. (µS/cm)	ORP (mV)	DO (mg/L)	Turbidity (NTU)	Flow Rate (ml/min)	Drawdown (feet)	Comments
1026	0.00	11.95	6.58	671	-130.2	14.81	9.5	200	1.0	Flow cell full
1036	0.25	11.61	6.51	273	-215.5	7.11	11	220		clear
1041	0.50	11.97	6.47	273	-234.1	7.85	8.1	150	1.58	"
1046	0.75	11.98	6.45	270	-238.6	3.91	8.0	150	1.44	"
1051	1.00	12.01	6.42	262	-244.0	1.03	8.7	150	1.44	"
1056	1.25	11.99	6.38	260	-246.2	1.06	12	150	1.46	"
1101	1.50	12.01	6.34	262	-248.1	1.10	16	150	1.47	"
1106	1.75	11.86	6.31	257	-250.6	1.13	19	160	1.53	"
1111	2.00	11.87	6.28	265	-249.4	1.15	19	180	1.59	"
1116	2.25	12.04	6.28	262	-242.4	1.22	18	150	1.51	"
1121	2.50	12.16	6.27	253	-234.7	1.28	18	150	1.52	"
1126	2.75	12.11	6.25	232	-236.7	1.37	19	170	1.52	"
1131	3.00	12.14	6.24	235	-237.8	1.36	18	150	1.53	"
1136	3.25	12.04	6.24	241	-237.7	1.33	16	150	1.53	"
1140	ready to sample									

(continued on back)

Sample Collector(s): Lu Burdick　　Date: 06/02/03

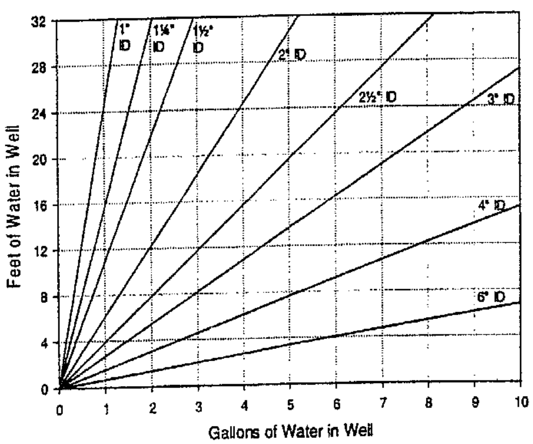
Well ID: MW-65S

(continued from front)

Time (24hr)	Volume Removed (literss)	Temp. (°C)	pH	Spec. Cond. (µS/cm)	ORP (mV)	DO (mg/L)	Turbidity (NTU)	Flow Rate (ml/min)	Drawdown (feet)	Comments

SAMPLE COLLECTION DATA

Sample ID	No. of Containers	Container Type	Preservation	Analysis	Time (24 hr)
MW-65S-gw-060203	3	40 ml	HCL	TCL VOCs	1208
"	2	1 L	4°C	2-Methlnapthalene	1208
MW-65S	1	500ml plastic	4°C	test kits	1208



Calculations:

tubing length	=	3	(add 3ft for pump)
	x	0.0217	Liters per foot
tubing vol.	=	0.065	
	+	0.25	(flow cell vol., L)
system vol.	=	$\boxed{0.315}$	(liters)

Volume per linear ft of tubing		
ID (in)	Gallon	Liter
0.250	0.0025	0.0097
0.375	0.0057	0.0217
0.500	0.0102	0.0386
0.750	0.0229	0.0869
1.000	0.0408	0.1544
1.250	0.0637	0.2413
1.500	0.0918	0.3475
2.000	0.1632	0.6178
2.500	0.2550	0.9653
3.000	0.3672	1.3900
4.000	0.6528	2.4711
6.000	1.4688	5.5600

Comments: A flow rate around 180 ml/min is appropriate
PID reading of purge water = ppm

Collector(s): Lai Bundrick Date: 06/02/03

LOW-FLOW DATA SHEET

Well I.D.: IW-5

Date: 6/30/03

Well Depth (from T.O.C.) = 19.00 ft

Well Diameter (d) = 1"

Static Water Level (WL) = 10.80 ft
(from T.O.C.)

FWENC Sampler(s): Yixian Zhang, Matt Greenberg

Parameters Sampled: ~~pH, Conductivity, DO, ORP, Temp.~~ TCL VOCs, 2 methylnapthalene

Tubing intake at 18.5 ft bgs.

Height of Water in Well (T):

T = depth (ft) - Static Water Level (ft)
T = ________ - ________
T = ________ ft

Time:	Temp.(°C) (± 3%)	pH (SU) (± 0.1)	Spec. Cond. (umhos/cm) (± 3%)	Turbidity (NTUs) (± 10%)	D.O. (mg/l) (±10%) 0.5mg/L if <1	ORP (mV) (± ~~10%~~ mV)	Flow Rate (ml/min)	Static Water Level	Comments (Vol Removed)
11:50	18.58	6.60	0.842		2.47	-169.3	175	11.70	Brown, turbid
12:00	15.90	6.26	0.907		1.62	-143.8	120	11.50	
12:05	15.99	6.24	0.919		1.55	-118.0	130	11.20	
12:10	17.10	6.27	0.926		1.50	-101.3	140	11.80	
12:15	15.32	6.21	0.911		1.42	-83.8	150	11.80	
12:20	15.16	6.23	0.890		1.28	-79.9	140	11.80	
12:25	15.40	6.24	0.884		1.21	-77.5	130	11.80	Becoming clearer
12:30	15.30	6.26	0.862		1.14	-75.0	130	11.85	
12:35	15.55	6.26	0.844		1.11	-70.9	50	11.90	
12:40	15.87	6.27	0.828		1.09	-70.4	110	11.95	
12:45	15.13	6.24	0.800		1.08	-65.5	100	11.90	
12:50	15.67	6.25	0.782		1.04	-66.9	100	11.90	
12:55	15.16	6.24	0.778		1.02	-64.8	100	11.90	
1355				8.36					

Total Volume Removed: 11:15 ~ 2 gals

1400 Collect sample. Label as IW-5-GW-063003.
Turbidity Meter had broken; waiting for a replacement. Will collect 1 turbidity reading prior to sampling.

LOW-FLOW DATA SHEET

Well I.D.: MW - 655

Date: 6-30-03

Well Depth (from T.O.C.) = 23.40 ft

Well Diameter (d) = 2"

Static Water Level (WL) = 11.30 ft
(from T.O.C.)

FWENC Sampler(s): M. Groenberg, Y. Zhang

Parameters Sampled: TCL VOCs, 2-methylnapthalene

Tubing intake at 17 ft bgs.

Height of Water in Well (T):

T = depth (ft) - Static Water Level (ft)
T = ______ - ______
T = ______ ft

Time:	Temp.(°C) (± 3%)	pH (SU) (± 0.1)	Spec. Cond. (umhos/cm) (± 3%)	Turbidity (NTUs) (± 10%)	D.O. (mg/l) (±10%) or.5mg/L if<1	ORP (mV) (± 10%) mV	Flow Rate (ml/min)	Static Water Level	Comments (Vol Removed)
1415	16.68	6.37	0.551	13.9	2.35	-44.6	200	11.82	
1420	14.56	6.35	0.433	14.2	1.28	-46.2	200	12.75	
1425	15.09	6.38	0.432	14.1	1.02	-49.2	160	12.80	
1430	14.96	6.37	0.446	8.80	1.06	-41.9	140	12.85	
1435	14.79	6.38	0.458	7.43	0.92	-49.0	120	12.85	
1440	14.58	6.41	0.457	7.15	0.84	-52.3	150	12.85	
1445	14.8	6.40	0.461	6.28	0.87	-56.3	150	13.00	
1450	14.09	6.43	0.461	6.81	0.75	-58.6	150	13.05	
1455	14.27	6.41	0.452	10.41	0.76	-56.0	150	13.10	
1500	14.40	6.37	0.440	14.7	0.74	-42.9	160	13.10	
1505	14.67	6.36	0.430	18.5	0.71	-24.6	120	13.25	
1510	15.37	6.34	0.466	16.6	0.73	-21.9	120	13.30	
1515	15.28	6.34	0.478	16.8	0.76	-28.5	120	13.37	
1520	14.97	6.35	0.488	14.6	0.72	-30.1	120	13.30	

Total Volume Removed: ~2.5 gals

1525 End purge of well. Await recharge.
1615 ~~1700~~ ~~1615~~ Collect sample from MW-655. Label as MW-655-GW-063003 and MS/MSD sample.

LOW-FLOW DATA SHEET

Well I.D.: MW-66S

Date: 6/30/03

Well Depth (from T.O.C.) = 18.20 ft

Well Diameter (d) = 2"

Static Water Level (WL) = 10.44 ft
(from T.O.C.)

FWENC Sampler(s): Matt Greenberg, Yixian Zhang

Parameters Sampled: ~~pH, Conductivity, DO, ORP~~ MG
TCL VOCs, 2-methylnapthalene

Height of Water in Well (T):

T = depth (ft) - Static Water Level (ft)
T = ________ - ________
T = ________ ft

Tubing intake at ~15 ft bgs.

Time:	Temp.(°C) (± 3%)	pH (SU) (± 0.1)	Spec. Cond. (umhos/cm) (± 3%)	Turbidity (NTUs) (± 10%)	D.O. (mg/l) (±10%) or 0.5 if <1	ORP (mV) mV (± 10%)	Flow Rate (ml/min)	Static Water Level	Comments
1425	17.72	6.72	0.517	11.8	4.21	-293.1	130	10.61	
1430	18.22	6.35	0.485	9.04	3.03	-274.1	175	10.82	
1435	15.97	6.26	0.472	8.26	2.65	-279.3	130	11.18	
1440	15.51	6.27	0.470	41.9	2.42	-263.7	180	11.52	
1445	15.13	6.29	0.468	30.2	2.34	-240.2	70	11.81	
1455	15.93	6.35	0.482	19.2	2.52	-198.2	150	11.84	
1500	15.10	6.29	0.475	9.62	2.35	-208.2	220	12.16	
1505	15.16	6.21	0.468	9.73	2.20	-195.5	50	12.25	
1510	15.75	6.22	0.473	8.13	2.23	-186.5	140	12.31	
1515	16.15	6.24	0.474	4.81	2.35	-155.1	100	12.39	
1520	15.71	6.22	0.470	3.88	2.46	-133.1	180	12.51	
1525	15.42	6.24	0.471	4.60	2.64	-131.4	160	12.70	
1530	15.11	6.24	0.473	9.10	2.68	-126.4	120	12.79	
1535	15.22	6.23	0.471	6.49	2.61	-123.2		12.88	

1538 End purge of well.

Total Volume Removed: ~2.5 gals.

1700 Collect sample, labeled as MW-66S-GW-063003.

1710 Duplicate sample time MW-66S-GW-063003D.

LOW-FLOW DATA SHEET

Well I.D.: MW-18SR

Date: 9/9/03

Well Depth (from T.O.C.) = 27.33 ft

Well Diameter (d) = 2"

Static Water Level (WL) = 16.52 ft from 5/29/03
(from T.O.C.)

FWENC Sampler(s): M. Ekas

Parameters Sampled: VOC's

Height of Water in Well (T):

T = depth (ft) - Static Water Level (ft)
T = 27.33 - 16.52
T = ____ ft

Tubing Depth ~ 25 ft TIC.

Time:	Temp.(°C) (± 3%)	pH (SU) (± 0.1)	Spec. Cond. (umhos/cm) (± 3%)	Turbidity (NTUs) (± 10%)	D.O. (mg/l) (±10%)	ORP (mV) (± 10%)	Flow Rate (ml/min)	Static Water Level	Comments
0934	52.95	6.19	254	644	3.23	25.1	500		purged well dry, at 0940
1023	21.74	6.30	461	17.6	4.14	25.0	100		PID 0.0
1029	26.50	6.11	236	1.85	3.37	-28.8	100		
1038	21.17	6.10	451	9.44	3.20	11.5	100		
1046	18.94	6.08	449	9.51	3.27	43.2	100		
1055	18.57	6.50	450	8.64	5.04	69.2	100		
1105	20.43	5.99	450	13.0	2.92	59.8	100		
1118	49.70	6.14	467	27.8	1.16	44.3	100		
1124	35.45	6.05	470	28.8	1.93	44.7	100		
1133	25.05	6.03	459	30.5	3.29	66.3	100		
1139	25.08	6.14	459	43.4	4.28	76.7	100		
1149	25.12	6.13	457	53.9	5.19	111.0	100		End purge.
1155	Sample	collected	for	TCL VOC'S					

Total Volume Removed: ~2.75 gals

A flow through cell not used
unexpected high temperatures.

LOW-FLOW DATA SHEET

Well I.D.: MW-63S

Date: 9-9-03

Well Depth (from T.O.C.) = 24.13 ft meas on 5-29-03

Well Diameter (d) = 2"

Static Water Level (WL) = 15.36 ft meas on 5-29-03
(from T.O.C.)
Tubing intake at ~22 ft TIC.

FWENC Sampler(s): M. Greenberg

Parameters Sampled: VOCs

Height of Water in Well (T):

T = depth (ft) - Static Water Level (ft)
T = ________ - ________
T = ________ ft

1119 Begin purging well. No flow through cell was used for fear of water running through it being too hot and causing damage to the meter. However, temperatures are lower than anticipated. Flow-through cell can be used in the future.

Time:	Temp.(°C) (± 3%)	pH (SU) (± 0.1)	Spec. Cond. (umhos/cm) (± 3%)	Turbidity (NTUs) (± 10%)	D.O. (mg/l) (±10%)	ORP (mV) (± 10%)	Flow Rate (ml/min)	Static Water Level	Comments
1120	31.73	5.98	771	5.91	5.92	137.0	125	NM	Water is slightly yellow.
1130	24.95	5.56	750	12.2	6.18	138.1	150	NM	"
1137	25.55	5.51	741	18.8	7.87	132.4	140	NM	"
1147	23.63	5.51	741	31.9	6.65	135.5	150	NM	"
1157	21.19	5.47	738	42.6	7.24	136.3	110	NM	"
1207	21.65	5.51	749	67.5	7.92	149.4	125	NM	"
1219				27.4			<20		

1227 Could not record ~~enough~~ MG readings at 1219; not enough water coming from well; it has almost dried, as far as can be told without water level meter. Will allow recharge for 15 minutes; sample will then be collected

1255 Collect sample MW-63S-GW-090903.

~~1305 Collect duplicate MW-63S-GW-090903D.~~ MG

Total Volume Removed: ~2 gals.

LOW-FLOW DATA SHEET

Well I.D.: MW-655

Date: 9/9/03

Well Depth (from T.O.C.) = 22.61 ft, meas. on 5-29-03

Well Diameter (d) = 2"

Static Water Level (WL) = 11.25 ft, meas. on 5-29-03
(from T.O.C.)

FWENC Sampler(s): mekas

Parameters Sampled: ~~TCL~~ VOCs (TCL)

Height of Water in Well (T):

T = depth (ft) - Static Water Level (ft)
T = ______ - ______
T = ______ ft

Time:	Temp.(°C) (± 3%)	pH (SU) (± 0.1)	Spec. Cond. (umhos/cm) (± 3%)	Turbidity (NTUs) (± 10%)	D.O. (mg/l) (±10%)	ORP (mV) (± 10%)	Flow Rate (ml/min)	Static Water Level	Comments
1337	44.45	6.76	443	25.6	1.38	50.3	180		
1345	34.22	5.74	458	21.0	3.29	45.1	150		
1350	27.64	5.84	452	17.2	2.97	40.3	150		
1355	25.87	5.74	429	17.9	1.87	48.4	150		
1400	25.30	5.75	425	17.2	1.85	48.7	150		
1406	24.68	5.69	437	17.7	1.70	56.3	150		ice added to coil
1410	21.68	5.66	423	18.4	1.96	55.2	150		
1415	20.54	5.67	422	16.3	1.87	70.1	150		
1420	20.97	5.94	417	16.2	1.48	73.9	150		
1425	19.62	6.00	414	16.8	1.51	59.8	150		
1430	21.24	5.96	416	15.1	1.47	68.1	150		
1435	21.83	6.03	414	16.2	1.40	70.5	150		
	1440	Sampled, Label as MW-655-GW-090903.							
	1445	Sampled (Dup), Label as MW-655-GW-090903D.							

Total Volume Removed: 2 gallon.

LOW-FLOW DATA SHEET

Well I.D.: MW-18 SR

Date: 09-30-03

Well Depth (from T.O.C.) = ______ ft

Well Diameter (d) = 2"

Static Water Level (WL) = 20.98 ft
(from T.O.C.)

FWENC Sampler(s): J. Verban

Parameters Sampled: VOC

Height of Water in Well (T):

T = depth (ft) - Static Water Level (ft)
T = ______ - ______
T = ______ ft

Time:	Temp.(°C) (± 3%)	pH (SU) (± 0.1)	Spec. Cond. (mmhos/cm) (± 3%)	Turbidity (NTUs) (± 10%)	D.O. (mg/l) (±10%)	ORP (mV) (± 10%)	Flow Rate (ml/min)	Static Water Level	Comments
1050	32.93	8.60	1.895	0.50	5.32	-180.2	150.	21.02	Replaced well tubing
1055	46.87	6.40	1.912	0.90	4.48	-88.0	200.	21.06	
1100	34.82	6.15	1.868	1.0	5.28	-29.0	200.	21.26	
1105	31.55	5.87	1.862	1.0	5.72	-3.6	200.	21.28	
1110	31.09	6.10	1.860	0.60	5.56	-8.1	200.	21.28	
1115	31.14	5.92	1.859	0.50	5.01	31.5	200.	21.29	
1120	30.47	5.78	1.858	0.60	4.87	43.8	200.	21.29	
1125	29.63	5.72	1.853	0.60	4.95	39.8	200.	21.29	
1130	29.62	5.71	1.859	0.50	4.94	38.2	200.	21.29	
1135									Sampling

Total Volume Removed: 2.25 gal

LOW-FLOW DATA SHEET

Well I.D.: MW-42 SR

Date: 9/30/03

Well Depth (from T.O.C.) = ______ ft

Well Diameter (d) = 2"

Static Water Level (WL) = 20.56 ft
(from T.O.C.)

FWENC Sampler(s): John Imhoff

Parameters Sampled: VOCs

Height of Water in Well (T):

T = depth (ft) - Static Water Level (ft)
T = ______ - ______
T = ______ ft

Time:	Temp.(°C) (± 3%)	pH (SU) (± 0.1)	Spec. Cond. (umhos/cm) (± 3%)	Turbidity (NTUs) (± 10%)	D.O. (mg/l) (±10%)	ORP (mV) (± 10%)	Flow Rate (ml/min)	Static Water Level	Comments
11:58	19.74	5.86	0.814 mS/cm^c	3.1	0.68	-26.3	30 ml/min	21.79	~~[illegible]~~
12:00	16.50	5.62	0.767 mS/cm^c	2.3	~~0.64~~ 0.78	-6.2	30 ml/min	21.79	~~[illegible]~~
12:05	16.89	5.61	0.769	2.1	0.80	-1.6	30 ml/min	21.79	~~[illegible]~~ 37
1210	16.93	5.61	0.769	2.3	0.92	2.3	30 ml/min	21.79	
1215	16.77	5.68	0.771	2.5	0.88	3.6	30 ml/min	21.79	
1220	16.54	5.54	0.773	2.4	0.87	10.0	30 ml/min	21.81	
1225	16.23	5.51	0.777	2.3	0.89	10.8	30 ml/min	21.81	
1230	15.98	5.47	0.775	1.8	0.91	16.0	30 ml/min	21.81	
1235	16.3	5.47	0.773	1.8	0.92	17.3	30 ml/min	21.81	Sample

Total Volume Removed: ______

LOW-FLOW DATA SHEET

Well I.D.: MW-60S

Date: 09-29-03

Well Depth (from T.O.C.) = 27. ft

Well Diameter (d) = 2"

Static Water Level (WL) = 22.88 ft
(from T.O.C.)

FWENC Sampler(s): J. Verban

Parameters Sampled: VOC

Height of Water in Well (T):

T = depth (ft) - Static Water Level (ft)
T = ______ - ______
T = ______ ft

Time:	Temp.(°C) (± 3%)	pH (SU) (± 0.1)	Spec. Cond. (mmhos/cm) (± 3%)	Turbidity (NTUs) (± 10%)	D.O. (mg/l) (±10%)	ORP (mV) (± 10%)	Flow Rate (ml/min)	Static Water Level	Comments
1615	14.71	8.79	0.662	8.2	1.17	-170.9	NM	24.93	WL stable
1620	13.17	9.53	0.663	6.6	0.60	-177.0		24.93	
1625	11.35	12.62	0.664	6.4	0.49	-242.4		24.93	
1630	11.09	13.93	0.665	6.0	0.47	-224.6		24.93	strange pH readings
1635	10.76	17.43	0.666	5.1	0.53	-235.6		24.93	
1640	10.57	15.88	0.667	4.3	0.69	-206.5		24.93	Sampling

Total Volume Removed: ______

LOW-FLOW DATA SHEET

Well I.D.: MW-61S

Date: 09-29-03

Well Depth (from T.O.C.) = 26. ft

Well Diameter (d) = 2"

Static Water Level (WL) = 21.19 ft
(from T.O.C.)

FWENC Sampler(s): J. Verba

Parameters Sampled: VOC

Height of Water in Well (T):

T = depth (ft) - Static Water Level (ft)
T = ______ - ______
T = ______ ft

Time:	Temp.(°C) (± 3%)	pH (SU) (± 0.1)	Spec. Cond. (~~μ~~mmhos/cm) (± 3%)	Turbidity (NTUs) (± 10%)	D.O. (mg/l) (±10%)	ORP (mV) (± 10%)	Flow Rate (ml/min)	Static Water Level	Comments
1530	14.45	6.11	0.657	5.4	0.92	126.3	NM	23.75	23.75 is bottom of tube 1.5 gal removed
0915	35.79	5.95	1.304		2.99	40.2	300. ml/min	23.09	
0930									Sampling

Total Volume Removed: ______

LOW-FLOW DATA SHEET

Well I.D.: MW-62S

Date: 10-01-03

Well Depth (from T.O.C.) = ______ ft

Well Diameter (d) = 2"

Static Water Level (WL) = 22.10 ft
(from T.O.C.)

FWENC Sampler(s): J. Verban

Parameters Sampled: VOC

Height of Water in Well (T):

T = depth (ft) - Static Water Level (ft)
T = ______ - ______
T = ______ ft

Time:	Temp.(°C) (± 3%)	pH (SU) (± 0.1)	Spec. Cond. (umhos/cm) (± 3%)	Turbidity (NTUs) (± 10%)	D.O. (mg/l) (±10%)	ORP (mV) (± 10%)	Flow Rate (ml/min)	Static Water Level	Comments
1030	19.31	6.20	0.565	3.7	4.91	-10.2	200.	22.54	
1035	17.49	6.08	0.577	5.7	0.97	-35.3	100.	22.88	
1040	16.64	6.02	0.551	7.9	1.16	-34.8	100.	23.01	
1045	14.46	5.96	0.547	10.	0.69	-35.0	100.	23.21	
1050	13.53	5.95	0.553	12.	0.60	-32.7	100.	23.41	
1100	14.97	6.01	0.561	13.	0.60	-34.0	100.	24.21	
1110	16.22	5.98	0.589	17.	0.48	-35.7	100.	24.66	WL continues to drop
									regardless of flowrate
1120								25.10	Well Dry
1140	10/2/03								→ Sampled

Total Volume Removed: 2. gal

LOW-FLOW DATA SHEET

Well I.D.: MW-638

Date: ~~9/30/03~~ 10-01-03

Well Depth (from T.O.C.) = ______ ft

Well Diameter (d) = 2"

Static Water Level (WL) = ~~20.44~~ 20.51 ft
(from T.O.C.)

FWENC Sampler(s): ~~John Imhoff~~ J. Vuban

Parameters Sampled: Voc

Height of Water in Well (T):

T = depth (ft) - Static Water Level (ft)
T = ______ - ______
T = ______ ft

Time:	Temp.(°C) (± 3%)	pH (SU) (± 0.1)	Spec. Cond. (mmhos/cm) (± 3%)	Turbidity (NTUs) (± 10%)	D.O. (mg/l) (±10%)	ORP (mV) (± 10%)	Flow Rate (ml/min)	Static Water Level	Comments
920	22.42	5.94	1.490	0.95	4.22	101.8	100.	21.15	
925	18.64	5.90	1.492	1.1	4.34	107.1	100.	21.17	
930	17.65	5.88	1.492	3.0	4.50	108.5	100.	21.17	
935	16.84	5.84	1.503	2.7	4.41	111.6	100.	21.17	
940									
									Sampling

Total Volume Removed: ______

LOW-FLOW DATA SHEET

Well I.D.: mw-64 S

Date: 9/29/03

Well Depth (from T.O.C.) = ______ ft

Well Diameter (d) = 2"

Static Water Level (WL) = ~~20.07~~ 19.85 ft
(from T.O.C.)
19.95 @ 0910 9/30/03

FWENC Sampler(s): John Imhoff

Parameters Sampled: VOCs

Height of Water in Well (T):

T = depth (ft) - Static Water Level (ft)
T = ______ - ______
T = ______ ft

Time:	Temp.(°C) (± 3%)	pH (SU) (± 0.1)	Spec. Cond. (umhos/cm) (± 3%)	Turbidity (NTUs) (± 10%)	D.O. (mg/l) (±10%)	ORP (mV) (± 10%)	Flow Rate (ml/min)	Static Water Level	Comments
9/29/03 1620	50.84	6.30	0.644 mS/cm		1.43	-4.2	–	22.47	dry. recharge + smpl in AM.
9/30/03 ~~0900~~ 0930	28.48	6.03	0.650 mS/cm	10	2.60	29.6		20.52	Burnt odor

Total Volume Removed: 2.0 gallons

P:/Sciences/Science.geo/Sci-form/LOWFLOW2.DOC

22.47 inlet of pump - dry @ 1620

LOW-FLOW DATA SHEET

Well I.D.: MW-65S

Date: 09-30-03

Well Depth (from T.O.C.) = ______ ft

Well Diameter (d) = 2'

Static Water Level (WL) = 18.89 ft
(from T.O.C.)

FWENC Sampler(s): J. Verbon

Parameters Sampled: VOC

Height of Water in Well (T):

T = depth (ft) - Static Water Level (ft)
T = ______ - ______
T = ______ ft

Time:	Temp.(°C) (± 3%)	pH (SU) (± 0.1)	Spec. Cond. (umhos/cm) (± 3%)	Turbidity (NTUs) (± 10%)	D.O. (mg/l) (±10%)	ORP (mV) (± 10%)	Flow Rate (ml/min)	Static Water Level	Comments
1545	24.05	8.31	1.420	1.1	0.79	-90.2	200.	19.50	
1550	23.91	9.68	1.422	1.0	0.61	-106.	200.	19.57	
1555	23.71	14.07	1.426	1.6	0.35	-168.	200.	19.71	
1600	24.82	15.21	1.426	0.95	0.37	-187.	200.	19.78	
1605	25.86	11.01	1.441	0.85	0.63	-136.	200.	19.96	
1610	24.27	6.62	1.458	0.90	0.73	-95.9	100.	20.00	Adjusted Flow
1615	24.93	8.18	1.466	0.60	0.76	-113.6	100.	20.00	
1620	25.37	9.64	1.473	0.50	0.46	-112.7	100.	20.00	
1640	25.47	8.07	1.479	0.50	0.89	-111.2	100.	20.00	
1645									Sampling

Total Volume Removed: ______

LOW-FLOW DATA SHEET

Well I.D.: MW- 66 S

Date: 10-01-03

Well Depth (from T.O.C.) = ______ ft

Well Diameter (d) = 2"

Static Water Level (WL) = 13.71 ft
(from T.O.C.)

FWENC Sampler(s): J. Verban

Parameters Sampled: VOC

Height of Water in Well (T):

T = depth (ft) - Static Water Level (ft)
T = ______ - ______
T = ______ ft

Time:	Temp.(°C) (± 3%)	pH (SU) (± 0.1)	Spec. Cond. (umhos/cm) (± 3%)	Turbidity (NTUs) (± 10%)	D.O. (mg/l) (±10%)	ORP (mV) (± 10%)	Flow Rate (ml/min)	Static Water Level	Comments
1200	21.41	6.48	0.560	5.2	0.58	9.2	200.	14.76	
1205	17.99	6.44	0.548	16.	0.66	13.6	200.	15.35	
1210	17.36	6.44	0.548	13.	0.53	13.1	200.	15.59	
1220	17.96	6.46	0.551	5.0	0.48	13.8	200.	16.20	
1230	21.44	6.51	0.556	2.8	0.45	5.9	200.	17.28	WL continues to drop
1235								17.40	w/slow recharge
									Well dry (below tube)
1400								17.01	Sampling
									Duplicate Here

Total Volume Removed: 3 gal

LOW-FLOW DATA SHEET

Project Name: Bedford, MA

Project No.: 2282.0891.9202.00000

Well I.D.: 18 SR

Date: 4/14/04

Well Depth (from T.O.C.) = 27.4 ft

Well Diameter (d) = ______ ft

Static Water Level (WL) = 15.91 ft
(from T.O.C.)

FWENC Sampler(s): Mance Ekas (TTFW), Lorie Burdick (ENSR)

Height of Water in Well (T):

T = depth (ft) - Static Water Level (ft)
T = 27.4 - 15.91
T = 11.49 ft.

Time:	Temp. (°C)	pH (SU)	Spec. Conduct (umhos/cm)	Turbidity (NTUs)	D.O. (mg/l)	Eh (mV)	Flow Rate (ml/min)	Static water Level	Color	Comments
0924	22.68	6.63	633	4.2	-3.01	-169.9	250	16.52	clear	odor - oil-like
0934	24.93	6.72	623	5.8	-1.86	-215.6	200	16.59	clear	"
0939	25.08	6.73	623	6.0	-1.72	-223.5	250	16.63	clear	"
0944	25.34	6.73	624	5.6	-1.53	-217.8	250	16.68	clear	"
0949	25.36	6.73	622	4.3	-1.52	-212.9	250	16.69	clear	odor less strong
0954	25.39	6.73	623	4.4	-1.42	-219.0	250	16.70	clear	odor ~~les~~ " "
0959	25.45	6.73	620	3.5	-1.45	-214.9	250	16.71	clear	" " "
1004	25.50	6.73	621	2.9	-1.41	-210.6	250	16.72	clear	odor
~~1007~~ 1010	Sample	Pump stopped mid sample - will re establish low flow params & re sample.								

Total Volume Removed: ______

Field Forms Templates (FF-4 Lowflow)
Proprietary Information

Version Date: 08/01/2001
Revision 1

LOW-FLOW DATA SHEET

Project Name: Bedford, MA

Project No.: 2282.0891.9202.00000

Well I.D.: MW 18SR

Date: 4/14/04

Well Depth (from T.O.C.) = ________ ft

Well Diameter (d) = ________ ft

Static Water Level (WL) = ________ ft
(from T.O.C.)

FWENC Sampler(s): Mance Ekas (TTFW), Lorie Burdick (ENSR)

Height of Water in Well (T):

T = depth (ft) - Static Water Level (ft)
T = ________ - ________
T = ________ ft

Time:	Temp. (°C)	pH (SU)	Spec. Conduct (umhos/cm)	Turbidity (NTUs)	D.O. (mg/l)	Eh (mV)	Flow Rate (ml/min)	Static water Level	Color	Comments
1025	24.97	6.75	626	2.2	-0.31	-208.6	250	16.58	clear	
1030	25.24	6.74	626	1.7	-0.73	-215.0	250	16.64	" "	
1035	25.31	6.73	624	1.2	-1.02	-216.4	250	16.65	" "	
1040	25.42	6.73	625	0.75	-1.01	-210.7	250	16.70	"	
1045	25.42	6.73	623	0.80	-0.91	-211.5	250	16.71	"	
sample @ 1050										

Total Volume Removed: 5 gal

Field Forms Templates (FF-4 Lowflow)
Proprietary Information

Version Date: 08/01/2001
Revision 1

LOW-FLOW DATA SHEET

Project Name: Bedford, MA

Project No.: 2282.0891.9202.00000

Well I.D.: MW-423R

Date: 4/13/04

Well Depth (from T.O.C.) = ~~15.32~~ 24.63 ft

Well Diameter (d) = ______ ft

Static Water Level (WL) = 15.32 ft (from T.O.C.)

FWENC Sampler(s): Mance Ekas (TTFW), Lorie Burdick (ENSR)

Height of Water in Well (T):

T = depth (ft) - Static Water Level (ft)
T = 24.63 - 15.32
T = 9.31 ft

sample @ 1500
Resample 1530

Time:	Temp. (°C)	pH (SU)	Spec. Conduct (umhos/cm)	Turbidity (NTUs)	D.O. (mg/l)	Eh (mV)	Flow Rate (ml/min)	Static water Level	Color	Comments
1348	15.13	6.45	47	126	0.97	-104.7	180	15.68	light brown	flow cell full
1358	18.12	5.97	37	90	1.28	-100.1	180	15.98	"	
1403	18.26	5.91	40	65	1.30	-136.1	200	16.05	"	
1408	18.28	5.86	44	45	1.17	-157.7	180	16.14	"	
1414	18.39	5.82	53	36	0.94	-160.0	200	16.21	clear	light rain
1418	18.45	5.82	59	25	0.81	-159.2	180	16.25	"	
1423	18.33	5.81	66	23	0.74	-157.3	180	16.28	"	
1428	18.35	5.81	76	19	0.66	-153.7	180	16.33	"	
1433	18.23	5.81	88	19	0.57	-152.8	180	16.37	"	
1438	18.25	5.81	95	14	0.44	-151.4	180	16.37	"	raining harder
1443	17.26	5.81	103	14	0.43	-148.2	180	16.29	"	
1448	16.93	5.81	114	14	0.39	-143.9	180	16.15	"	
1453	17.30	5.81	118	13	0.36	-142.0	180	16.14		

Total Volume Removed: 3.25g

LOW-FLOW DATA SHEET

Project Name: Bedford, MA

Project No.: 2282.0891.9202.00000

Well I.D.: MW 605

Date: 4/14/04

Well Depth (from T.O.C.) = ______ ft

Well Diameter (d) = ______ ft

Static Water Level (WL) = 19.18' ft
(from T.O.C.)

FWENC Sampler(s): Mance Ekas (TTFW), Lorie Burdick (ENSR)

Height of Water in Well (T):

T = depth (ft) - Static Water Level (ft)
T = ______ - ______
T = ______ ft

Time:	Temp. (°C)	pH (SU)	Spec. Conduct (umhos/cm)	Turbidity (NTUs)	D.O. (mg/l)	Eh (mV)	Flow Rate (ml/min)	Static water Level	Color	Comments
0920	20.12	6.18	367	2.8	1.25	-51.4	150	19.30	Clear	
0925	21.28	6.17	362	2.7	0.83	-46.8	180	19.41	" "	
0930	22.32	6.14	341	2.7	0.68	-50.2	180	19.75	" "	
0935	21.83	6.14	340	4.3	0.63	-61.3	150	19.80	" "	
0940	21.61	6.13	332	5.1	0.54	-62.4	150	19.86	" "	
0945	21.96	6.12	323	5.0	0.43	-67.7	150	19.89	" "	
0950	21.99	6.12	323	4.2	0.38	-76.4	150	20.14	" "	
1000	22.00	6.13	327	5.7	0.30	-88.0	150	20.20	" "	
1005	22.11	6.14	336	4.5	0.30	-95.7	150	20.27	" "	
1010	22.11	6.14	332	4.3	0.29	-102.5	150	20.30	" "	
1015	22.17	6.15	336	4.3	0.28	-103.9	150	20.41	" "	
1020	Sampled.									

Total Volume Removed: ______

LOW-FLOW DATA SHEET

Project Name: Bedford, MA

Project No.: 2282.0891.9202.00000

Well I.D.: mw- 61S

Date: 4/13/04

Well Depth (from T.O.C.) = ______ ft

Well Diameter (d) = ______ ft

Static Water Level (WL) = 16.29 ft
(from T.O.C.)

FWENC Sampler(s): Mance Ekas (TTFW), Lorie Burdick (ENSR)

Height of Water in Well (T):

T = depth (ft) - Static Water Level (ft)
T = ______ - ______
T = ______ ft

Time:	Temp. (°C)	pH (SU)	Spec. Conduct (umhos/cm)	Turbidity (NTUs)	D.O. (mg/l)	Eh (mV)	Flow Rate (ml/min)	Static water Level	Color	Comments
1113	18.02	5.71	436	14	0.62	72.3	200	16.57	clear	
1118	20.18	5.70	432	15	0.62	73.4	180	16.82	" "	
1126	20.26	5.69	428	17	0.56	91.0	200	17.16	" "	
1132	19.42	5.68	427	21	0.46	82.9	200	17.56	" "	
1138	19.49	5.69	427	22	0.48	79.7	200	17.77		
	1145	Sampled.								

Total Volume Removed: ______

LOW-FLOW DATA SHEET

Project Name: Bedford, MA

Project No.: 2282.0891.9202.00000

Well I.D.: mw 625

Date: 4/13/04

Well Depth (from T.O.C.) = ______ ft

Well Diameter (d) = ______ ft

Static Water Level (WL) = 17.06 ft
(from T.O.C.)

FWENC Sampler(s): Mance Ekas (TTFW), Lorie Burdick (ENSR)

Height of Water in Well (T):

T = depth (ft) - Static Water Level (ft)
T = ______ - ______
T = ______ ft

Time:	Temp. (°C)	pH (SU)	Spec. Conduct (umhos/cm)	Turbidity (NTUs)	D.O. (mg/l)	Eh (mV)	Flow Rate (ml/min)	Static water Level	Color	Comments
1350	19.74	5.38	444	0.85	0.45	123.3	200	17.32	clear	
1400	21.08	5.34	445	1.3	0.25	129.0	180	17.75	" "	
1405	21.10	5.33	443	2.6	0.19	131.1	180	17.95	" "	
1411	20.75	5.30	447	3.9	0.19	132.2	200	18.29	" "	
1417	20.83	5.29	454	5.3	0.16	130.2	200	18.47	" "	
1422	21.1	5.30	459	5.5	0.28	126.0	180	18.59	" "	
1427	20.82	5.32	460	5.5	0.18	128.9	180	18.70		
	Sampled at		1435	dup	Taken					

Total Volume Removed: ______

Field Forms Templates (FF-4 Lowflow)
Proprietary Information

Version Date: 08/01/2001
Revision 1

LOW-FLOW DATA SHEET

Project Name: Bedford, MA

Project No.: 2282.0891.9202.00000

Well I.D.: MW-63S

Date: 4/14/04

Well Depth (from T.O.C.) = 24.04 ft

Well Diameter (d) = ______ ft

Static Water Level (WL) = 14.78 ft
(from T.O.C.)

FWENC Sampler(s): Mance Ekas (TTFW), Lorie Burdick (ENSR)

Height of Water in Well (T):

T = depth (ft) - Static Water Level (ft)
T = 24.04 - 14.78
T = 9.26 ft

Time:	Temp. (°C)	pH (SU)	Spec. Conduct (umhos/cm)	Turbidity (NTUs)	D.O. (mg/l)	Eh (mV)	Flow Rate (ml/min)	Static water Level	Color	Comments
1113	20.94	6.62	388	45	-1.75	-101.6	250	15.12	clear	flow cell full
1118	21.78	6.39	367	37	-1.10	-91.9	250	15.25	clear	
1123	21.91	6.34	365	33	-0.91	-98.7	250	15.55	clear	
1128	21.93	6.34	368	24	-0.91	-99.0	250	15.92	clear	
1133	21.96	6.34	372	17	-0.83	-116.4	250	16.12	clear	
1138	21.98	6.37	384	13	-0.13	-125.2	250	16.26	clear	
1143	22.08	6.41	401	10	-0.46	-121.8	250	16.34	clear	
1148	22.17	~~6.43~~	413	8.0	-0.63	-132.9	250	16.45	clear	
1153	22.27	6.46	427	6.3	-0.54	-142.6	250	16.53	clear	
1158	22.37	6.50	439	5.6	-0.63	-147.4	250	16.58	clear	
1203	22.50	6.52	452	4.2	-0.62	-152.2	250	16.62	clear	
1208	22.55	6.55	467	3.5	-0.58	-157.3	250	16.66	clear	
1213	22.48	6.55	472	3.1	-0.64	-157.1				

Total Volume Removed: 5 g

Sample @ 1220

Field Forms Templates (FF-4 Lowflow)
Proprietary Information

Version Date: 08/01/2001
Revision 1

9/16
1211

LOW-FLOW DATA SHEET

Project Name: Bedford, MA

Project No.: 2282.0891.9202.00000

Well I.D.: MW 645

Date: 4/14/04

Well Depth (from T.O.C.) = ______ ft

Well Diameter (d) = ______ ft

Static Water Level (WL) = 14.52 ft
(from T.O.C.)

FWENC Sampler(s): Mance Ekas (TTFW), Lorie Burdick (ENSR)

Height of Water in Well (T):

T = depth (ft) - Static Water Level (ft)
T = ______ - ______
T = ______ ft

Time:	Temp. (°C)	pH (SU)	Spec. Conduct (umhos/cm)	Turbidity (NTUs)	D.O. (mg/l)	Eh (mV)	Flow Rate (ml/min)	Static water Level	Color	Comments
1105	20.53	6.05	325	1.20	0.75	-21.8	200	14.60	Clear	
1110	21.26	6.05	320	1.29	0.59	-23.5	200	14.60	" "	
1115	21.67	6.03	317	1.01	0.42	-22.8	180	14.66	" "	
1120	21.63	6.03	316	1.13	0.43	-23.0	200	14.70	" "	
1125	21.53	6.00	313	0.92	0.34	-21.4	200	14.76	" "	
1130	21.41	5.98	311	0.96	0.27	-19.8	200	14.80	" "	
1135	21.25	5.96	310	0.59	0.23	-17.1	200	14.85	" "	
1140	20.98	5.93	309	0.94	0.24	-12.8	200	14.87	" "	
1145	20.99	5.92	308	1.24	0.29	-10.5	200	14.90		
1150	21.00	5.91	309	1.08	0.29	-9.4	200	14.90		
Sampled at		1155								

Total Volume Removed: ______

Field Forms Templates (FF-4 Lowflow)
Proprietary Information

Version Date: 08/01/2001
Revision 1

LOW-FLOW DATA SHEET

Project Name: Bedford, MA

Project No.: 2282.0891.9202.00000

Well I.D.: mw 655

Date: 4/14/04

Well Depth (from T.O.C.) = ______ ft

Well Diameter (d) = ______ ft

Static Water Level (WL) = 11.35 ft
(from T.O.C.)

FWENC Sampler(s): Mance Ekas (TTFW), Lorie Burdick (ENSR)

Height of Water in Well (T):

T = depth (ft) - Static Water Level (ft)
T = ______ - ______
T = ______ ft

Time:	Temp. (°C)	pH (SU)	Spec. Conduct (umhos/cm)	Turbidity (NTUs)	D.O. (mg/l)	Eh (mV)	Flow Rate (ml/min)	Static water Level	Color	Comments
1225	16.84	6.69	452	3.99	2.16	-136.9	350	12.05	clear	
1230	17.55	6.79	453	3.09	0.72	-166.6	180	12.64	" "	
1235	17.52	6.80	457	2.68	0.32	-173.9	180	13.15	" "	
1240	17.41	6.81	461	1.70	0.25	-180.7	150	13.22	" "	
1245	17.52	6.82	466	1.69	0.25	-184.4	150	13.30	" "	
1250	17.70	6.82	468	1.05	0.23	-187.1	150	13.20		
1255	17.84	6.82	472	1.91	0.19	-189.9	150	13.21		
1300	17.85	6.82	474	1.87	0.19	-190.8	150	13.21		
1305	17.86	6.83	475	1.34	0.18	-191.3	150	13.21		
	1310	Sampled.								

Total Volume Removed: ______

6.89
6.62
6.60

LOW-FLOW DATA SHEET

Project Name: Bedford, MA

Well I.D.: MW-66S

Well Depth (from T.O.C.) = 18.45 ft

Static Water Level (WL) = 10.37 ft
(from T.O.C.)

3.89
3.79
3.75

Project No.: 2282.0891.9202.00000

Date: 4/13/04

Well Diameter (d) = ______ ft

FWENC Sampler(s): Mance Ekas (TTFW), Lorie Burdick (ENSR)

Height of Water in Well (T):

T = depth (ft) - Static Water Level (ft)
T = 18.45 - 10.37
T = 8.08 ft

Time:	Temp. (°C)	pH (SU)	Spec. Conduct (umhos/cm)	Turbidity (NTUs)	D.O. (mg/l)	Eh (mV)	Flow Rate (ml/min)	Static water Level	Color	Comments
1030	11.65	[illegible] 6.37	[illegible]	12	-0.87	-110.3	180	10.60	brown	[illegible] full
1040	12.17	6.62 6.62	3.79	9.3	-1.04	-98.4	150	10.85	clear	odor? - can't tell what
1050	12.23	6.61	3.75	7.3	-1.07	-96.3	180	11.10	clear	
1055	12.23	6.60	3.74	5.6	-1.06	-95.8	180	11.24	clear	
1100	12.38	6.60	3.73	5.8	-1.04	-96.8	180	11.45	clear	
1105	12.27	6.60	3.72	4.4	-1.00	-96.8	180	11.75	clear	
	MS/MSD + sample									

Total Volume Removed: 2.5 g

Field Forms Templates (FF-4 Lowflow)
Proprietary Information

Version Date: 08/01/2001
Revision 1

APPENDIX E

Summary of Analytical Results – Soil

Table E-1
Soil Analytical Results
Site 4 ERH Remediation
Bedford NWIRP Site
Bedford, Massachusetts

Sample ID	**MW-60S-SBC-051403**		**MW-61S-SBA-051503**		**MW-62S-SBA-051503**		**MW-62S-SBA-051503D**		**MW-63S-SBA-051603**		**MW-64S-SBA-051603**		**MW-65S-SBA-051703**		**MW-66S-SBA-062603**	
Date Collected	**5/14/2003**		**5/15/2003**		**5/15/2003**		**5/15/2003**		**5/16/2003**		**5/16/2003**		**5/17/2003**		**6/26/2003**	
Depth Collected (ft bgs)	**25.5**		**20.0**		**21.5**		**21.5**		**17.5**		**16.5**		**16.0**		**4.5**	
Analyte	**ug/kg**	**Qual.**	**ug/kg**	**Qual.**	**ug/kg**	**Qual.**	**ug/kg**	**Qual.**	**ug/kg**	**Qual.**	**ug/kg**	**Qual.**	**ug/kg**	**Qual.**	**ug/kg**	**Qual.**
TCL VOCs																
1,1,1-Trichloroethane	1400	U	1600	U	740	U	480	U	2800	U	760	U	2700	U	75	U
1,1,2,2,-Tetrachloroethane	1400	U	1600	U	740	U	480	U	2800	U	760	U	2700	U	75	U
1,1,2-Trichloroethane	1400	U	1600	U	740	U	480	U	2800	U	760	U	2700	U	75	U
1,1-Dichloroethane	1400	U	1600	U	740	U	480	U	2800	U	760	U	2700	U	75	U
1,1-Dichloroethene	1400	U	1600	U	740	U	480	U	2800	U	760	U	2700	U	75	U
1,2-Dichloroethane	1400	U	1600	U	740	U	480	U	2800	U	760	U	2700	U	75	U
1,2-Dichloropropane	1400	U	1600	U	740	U	480	U	2800	U	760	U	2700	U	75	U
2-Butanone	3400	U	4100	U	1900	U	1200	U	7000	U	1900	U	6700	U	75	U
2-Hexanone	1400	U	1600	U	740	U	480	U	2800	U	760	U	2700	U	75	U
4-Methyl-2-pentanone	1400	U	1600	U	740	U	480	U	2800	U	760	U	2700	U	75	U
Acetone	3400	U	3200	U	1900	U	1000	U	3700	U	850	U	6700	U	180	U
Benzene*	1400	U	1600	U	740	U	480	U	2800	U	760	U	2700	U	75	U
Bromodichloromethane	1400	U	1600	U	740	U	480	U	2800	U	760	U	2700	U	75	U
Bromoform	1400	U	1600	U	740	U	480	U	2800	U	760	U	2700	U	75	U
Bromomethane	3400	U	**1100**	**J**	410	U	1200	U	7000	U	1900	U	6700	U	190	U
Carbon disulfide	1400	U	1600	U	740	U	480	U	2800	U	760	U	2700	U	75	U
Carbon tetrachloride	1400	U	1600	U	740	U	480	U	2800	U	760	U	2700	U	75	U
Chlorobenzene	1400	U	1600	U	740	U	480	U	2800	U	760	U	2700	U	75	U
Chloroethane	1400	U	1600	U	740	U	480	U	2800	U	760	U	2700	U	75	U
Chloroform	1400	U	1600	U	740	U	480	U	2800	U	760	U	2700	U	75	U
Chloromethane	1400	U	1600	U	740	U	480	U	2800	U	760	U	2700	U	75	U
Cis-1,2-Dichloroethene	1400	U	1600	U	740	U	480	U	2800	U	760	U	2700	U	75	U
Cis-1,3-dichloropropene	1400	U	1600	U	740	U	480	U	2800	U	760	U	2700	U	75	U
Dibromochloromethane	1400	U	1600	U	740	U	480	U	2800	U	760	U	2700	U	75	U
Ethylbenzene*	**23000**		**1800**		740	U	480	U	**42000**		**2400**		**50000**		**40**	**J**
Methylene chloride	3400	U	4100	U	1900	U	1200	U	7000	U	1900	U	6700	U	190	U
Methyl-tert-butyl ether	1400	U	1600	U	740	U	480	U	2800	U	760	U	2700	U	75	U
Naphthalene	**6500**		**5300**		**540**	**J**	**390**	**J**	**16000**		**3500**		**17000**		75	U
Styrene	1400	U	1600	U	740	U	480	U	2800	U	760	U	2700	U	75	U
Tetrachloroethene	1400	U	1600	U	740	U	480	U	2800	U	760	U	2700	U	75	U
Toluene*	**7600**		**7600**		740	U	480	U	**31000**		**2300**		**30000**		75	U
Trans 1,2-dichloroethene	1400	U	1600	U	740	U	480	U	2800	U	760	U	2700	U	75	U
Trans-1,3-dichloropropene	1400	U	1600	U	740	U	480	U	2800	U	760	U	2700	U	75	U
Trichloroethene	1400	U	1600	U	740	U	480	U	2800	U	760	U	2700	U	75	U
Vinyl chloride	1400	U	1600	U	740	U	480	U	2800	U	760	U	2700	U	75	U
p/m - Xylene*	**86000**		**69000**		**790**	**J**	**510**	**J**	**260000**		**61000**		**210000**		150	U
o-Xylene*	**23000**		**35000**		740	U	480	U	**86000**		**22000**		**56000**		75	U
Total VOCs	**146100**		**119800**		**1330**		**900**		**435000**		**91200**		**363000**		**40**	
Total BTEX	**139600**		**113400**		**790**		**510**		**419000**		**87700**		**346000**		**40**	
SVOCs																
2-Methylnaphthalene	**340**		**330**		**120**	**J**	**190**	**J**	**770**		**450**		**320**		53	U

Notes:
Analyte with "*" indicates that it is a Contaminant of Concern (COC).
U = Non-detect
J = Analyte was detected below its reporting limit. The result was estimated.
ft bgs = feet below ground surface

APPENDIX F

Summary of Analytical Results – Groundwater

Table F-1
Groundwater Analytical Results
Site 4 ERH Remediation
Bedford NWIRP Site
Bedford, Massachusetts

Sample Location	MW-18SR							
Date Collected	6/2/2003		9/9/2003		9/30/2003		4/14/2004	
Sampling Event	Pre-Treatment		Mid-Process		Post-Treatment		Long-Term Monitoring	
Sample Collection Method	peristaltic pump		peristaltic pump		peristaltic pump		peristaltic pump	
Analyte	Conc. (ug/L)	Qual.	Conc. (ug/L)	Qual.	Conc. (ug/L)	Qual.	Conc. (ug/L)	Qual.
TCL VOCs								
1,1,1-Trichloroethane	40	U	2.0	U	4.0	U	2	U
1,1,2,2,-Tetrachloroethane	40	U	2.0	U	4.0	U	2	U
1,1,2-Trichloroethane	40	U	2.0	U	4.0	U	2	U
1,1-Dichloroethane	40	U	2.0	U	4.0	U	1.4	J
1,1-Dichloroethene	40	U	2.0	U	4.0	U	1.6	J
1,2-Dichloroethane	40	U	2.0	U	4.0	U	2	U
1,2-Dichloropropane	40	U	2.0	U	4.0	U	2	U
2-Butanone	42		12		91		4.4	
2-Hexanone	40	U	5.0	U	2.7	J	1.3	J
4-Methyl-2-pentanone	40	U	5.0	U	4.0	U	3.7	
Acetone	99	J	180		760		11	
Benzene*	220		2.0	U	3.3	J	41	
Bromodichloromethane	40	U	2.0	U	4.0	U	2	U
Bromoform	40	U	2.0	U	4.0	U	2	U
Bromomethane	100	U	5.0	U	4.0	U	2	U
Carbon disulfide	40	U	1.0	J	4.0	U	2	U
Carbon tetrachloride	40	U	2.0	U	4.0	U	2	U
Chlorobenzene	40	U	2.0	U	4.0	U	2	U
Chloroethane	40	U	2.0	U	4.0	U	2	U
Chloroform	40	U	2.0	U	4.0	U	2	U
Chloromethane	40	U	2.0	U	4.0	U	2	U
1,2-Dichloroethene (total)	40	U	2.0	U	4.0	U	16	
Cis-1,3-dichloropropene	40	U	2.0	U	4.0	U	2	U
Dibromochloromethane	40	U	2.0	U	4.0	U	2	U
Ethylbenzene*	1200		3.1		15		650	
Methylene chloride	100	U	5.0	U	10	U	5	U
Methyl-tert-butyl ether	40	U	2.0	U	4.0	U	2	U
Naphthalene	290		2.5	J	40.0		390	
Styrene	40	U	5.0	U	4.0	U	3.2	
Tetrachloroethene	40	U	2.0	U	4.0	U	2	U
Toluene*	2200		6.8		24		13	
Trans-1,3-dichloropropene	40	U	2.0	U	4.0	U	2	U
Trichloroethene	29	J	2.0	U	4.0	U	1.9	J
Vinyl chloride	40	U	2.0	U	4.0	U	2	U
p/m - Xylene*	3600		18		64		800	
o-Xylene*	1500		2.7		40		50	
Total VOCs	9180		226.1		1040		1961	
Total BTEX	8720		30.6		146		1554	
SVOC								
2-Methylnaphthalene	42		NA		NA		37	
Benzene % Reduction (from 6/2/03)			99%		99%		81%	
Total BTEX % Reduction (from 6/2/03)			100%		98%		82%	
Low Flow Parameters								
Temp (C)	13.5		25.1		29.6		25.4	
pH	6.28		6.13		5.71		6.73	
Spec. Conductivity (umhos/cm)	431		457		1859		623	
Turbidity (NTUs)	6.0		53.9		0.5		0.8	
D.O. (mg/l)	0.48		5.19		4.94		-0.91	
ORP (mV)	-150.0		111.0		38.2		-211.5	
Flow Rate (ml/min)	150		100		200		250	

Sample Location	MW-42SR					
Date Collected	6/2/2003		9/30/2003		4/13/2004	
Sampling Event	Pre-Treatment		Post-Treatment		Long-Term Monitoring	
Sample Collection Method	peristaltic pump		peristaltic pump		peristaltic pump	
Analyte	Conc. (ug/L)	Qual.	Conc. (ug/L)	Qual.	Conc. (ug/L)	Qual.
TCL VOCs						
1,1,1-Trichloroethane	2.0	U	10	U	2	U
1,1,2,2,-Tetrachloroethane	2.0	U	10	U	2	U
1,1,2-Trichloroethane	2.0	U	10	U	2	U
1,1-Dichloroethane	2.0	U	10	U	2	U
1,1-Dichloroethene	2.0	U	10	U	2	U
1,2-Dichloroethane	2.0	U	10	U	2	U
1,2-Dichloropropane	2.0	U	10	U	2	U
2-Butanone	8.7		11		2.5	
2-Hexanone	2.0	U	10	U	2	U
4-Methyl-2-pentanone	2.0	U	10	U	2	U
Acetone	29		39		8.5	
Benzene*	14		20		2.2	
Bromodichloromethane	2.0	U	10	U	2	U
Bromoform	2.0	U	10	U	2	U
Bromomethane	5.0	U	10	U	2	U
Carbon disulfide	2.0	U	10	U	2	U
Carbon tetrachloride	2.0	U	10	U	2	U
Chlorobenzene	2.0	U	10	U	2	U
Chloroethane	2.0	U	10	U	2	U
Chloroform	2.0	U	10	U	2	U
Chloromethane	2.0	U	10	U	2	U
1,2-Dichloroethene (total)	2.0	U	10	U	2	U
Cis-1,3-dichloropropene	2.0	U	10	U	2	U
Dibromochloromethane	2.0	U	10	U	2	U
Ethylbenzene*	34		65		15	
Methylene chloride	5.0	U	25	U	5	U
Methyl-tert-butyl ether	2.0	U	10	U	2	U
Naphthalene	11		28		5.1	
Styrene	2.0	U	10	U	2	U
Tetrachloroethene	2.0	U	10	U	2	U
Toluene*	1.5	J	7.4	J	2	U
Trans-1,3-dichloropropene	2.0	U	10	U	2	U
Trichloroethene	1.2	J	10	U	2	U
Vinyl chloride	2.0	U	10	U	2	U
p/m - Xylene*	22		71		14	
o-Xylene*	1.2	J	18		2	U
Total VOCs	122.6		259.4		51.3	
Total BTEX	72.7		181.4		35.2	
SVOC						
2-Methylnaphthalene	5.8		NA		0.27	U
Benzene % Reduction (from 6/2/03)			-43%		84%	
Total BTEX % Reduction (from 6/2/03)			-150%		52%	
Low Flow Parameters						
Temp (C)	14.4		16.3		17.3	
pH	6.60		5.47		5.81	
Spec. Conductivity (umhos/cm)	121		773		118	
Turbidity (NTUs)	45.0		1.8		13.0	
D.O. (mg/l)	1.50		0.92		0.36	
ORP (mV)	-7.0		17.3		-142.0	
Flow Rate (ml/min)	160		30		180	

Sample Location	MW-60S							
Date Collected	5/29/2003		5/29/2003, Duplicate		9/29/2003		4/14/2004	
Sampling Event	Pre-Treatment		Pre-Treatment		Post-Treatment		Long-Term Monitoring	
Sample Collection Method	peristaltic pump		peristaltic pump		peristaltic pump		peristaltic pump	
Analyte	Conc. (ug/L)	Qual.	Conc. (ug/L)	Qual.	Conc. (ug/L)	Qual.	Conc. (ug/L)	Qual.
TCL VOCs								
1,1,1-Trichloroethane	40	U	40	U	40	U	2	U
1,1,2,2,-Tetrachloroethane	40	U	40	U	40	U	2	U
1,1,2-Trichloroethane	40	U	40	U	40	U	2	U
1,1-Dichloroethane	40	U	40	U	40	U	2	U
1,1-Dichloroethene	40	U	40	U	40	U	2	U
1,2-Dichloroethane	40	U	40	U	40	U	2	U
1,2-Dichloropropane	40	U	40	U	40	U	2	U
2-Butanone	46		110		26	J	1.8	J
2-Hexanone	40	U	40	U	40	U	1.6	J
4-Methyl-2-pentanone	40	U	40	U	40	U	2	U
Acetone	110		210		73	J	4.1	J
Benzene*	250		250		140		7.6	
Bromodichloromethane	40	U	40	U	40	U	2	U
Bromoform	40	U	40	U	40	U	2	U
Bromomethane	100	U	100	U	40	U	2	U
Carbon disulfide	40	U	40	U	40	U	2	U
Carbon tetrachloride	40	U	40	U	40	U	2	U
Chlorobenzene	40	U	40	U	40	U	2	U
Chloroethane	40	U	40	U	40	U	2	U
Chloroform	40	U	40	U	40	U	2	U
Chloromethane	40	U	40	U	40	U	2	U
1,2-Dichloroethene (total)	40	U	40	U	40	U	4.5	
Cis-1,3-dichloropropene	40	U	40	U	40	U	2	U
Dibromochloromethane	40	U	40	U	40	U	2	U
Ethylbenzene*	1600		1700		2100		97	
Methylene chloride	100	U	100	U	100	U	5	U
Methyl-tert-butyl ether	40	U	40	U	40	U	2	U
Naphthalene	320		380		600		52	
Styrene		U	40	U	40	U	2	U
Tetrachloroethene		U	40	U	40	U	2	U
Toluene*	1800		2300		670		1.3	J
Trans-1,3-dichloropropene	40	U	40	U	40	U	2	U
Trichloroethene	40	U	40	U	40	U	1.4	J
Vinyl chloride	40	U	40	U	40	U	2	U
p/m - Xylene*	3500		3800		4600		26	
o-Xylene*	1200		1800		1100		6.5	
Total VOCs	8826		10550		9309		196.3	
Total BTEX	8350		9850		8610		138.4	
SVOC								
2-Methylnaphthalene	30		39		NA		6.9	
Benzene % Reduction (from 6/2/03)					44%		97%	
Total BTEX % Reduction (from 6/2/03)					-3%		98%	
Low Flow Parameters								
Temp (C)	13.1		13.1		10.6		22.2	
pH	6.21		6.21		5.88		6.15	
Spec. Conductivity (umhos/cm)	783		783		667		336	
Turbidity (NTUs)	4.8		4.8		4.3		4.3	
D.O. (mg/l)	0.37		0.37		0.69		0.28	
ORP (mV)	-127.2		-127.2		-206.5		-103.9	
Flow Rate (ml/min)	150		150		NR		150	

Sample Location	MW-61S					
Date Collected	5/30/2003		9/30/2003		4/13/2004	
Sampling Event	Pre-Treatment		Post-Treatment		Long-Term Monitoring	
Sample Collection Method	peristaltic pump		peristaltic pump		peristaltic pump	
Analyte	Conc. (ug/L)	Qual.	Conc. (ug/L)	Qual.	Conc. (ug/L)	Qual.
TCL VOCs						
1,1,1-Trichloroethane	100	U	20	U	2	U
1,1,2,2,-Tetrachloroethane	100	U	20	U	2	U
1,1,2-Trichloroethane	100	U	20	U	2	U
1,1-Dichloroethane	100	U	20	U	2	U
1,1-Dichloroethene	100	U	20	U	2	U
1,2-Dichloroethane	100	U	20	U	2	U
1,2-Dichloropropane	100	U	20	U	2	U
2-Butanone	110		97		2	J
2-Hexanone	100	U	20	U	4	
4-Methyl-2-pentanone	100	U	20	U	1	J
Acetone	190	J	320		4	J
Benzene*	76	J	14	J	2	U
Bromodichloromethane	100	U	20	U	2	U
Bromoform	100	U	20	U	2	U
Bromomethane	250	U	20	U	2	U
Carbon disulfide	100	U	20	U	2	U
Carbon tetrachloride	100	U	20	U	2	U
Chlorobenzene	100	U	20	U	2	U
Chloroethane	100	U	20	U	2	U
Chloroform	100	U	20	U	2	U
Chloromethane	100	U	20	U	2	U
1,2-Dichloroethene (total)	100	U	20	U	2	U
Cis-1,3-dichloropropene	100	U	20	U	2	U
Dibromochloromethane	100	U	20	U	2	U
Ethylbenzene*	290		650		2	U
Methylene chloride	250	U	50	U	5	U
Methyl-tert-butyl ether	100	U	20	U	2	U
Naphthalene	240		170		1.2	J
Styrene	100	U	20	U	2	U
Tetrachloroethene	100	U	20	U	2	U
Toluene*	3800		830		2	U
Trans-1,3-dichloropropene	100	U	20	U	2	U
Trichloroethene	100	U	20	U	2	U
Vinyl chloride	100	U	20	U	2	U
p/m - Xylene*	7800		3300		34	
o-Xylene*	4800		1900		16	
Total VOCs	17306		7281		63.2	
Total BTEX	16766		6694		56	
SVOC						
2-Methylnaphthalene	42		NA		0.25	U
Benzene % Reduction (from 6/2/03)			82%		97%	
Total BTEX % Reduction (from 6/2/03)			60%		100%	
Low Flow Parameters						
Temp (C)	12.8		35.8		20.0	
pH	5.93		5.95		5.69	
Spec. Conductivity (umhos/cm)	443		1304		427	
Turbidity (NTUs)	14.0		5.4		22.0	
D.O. (mg/l)	2.44		2.99		0.48	
ORP (mV)	91.7		40.2		79.7	
Flow Rate (ml/min)	150		300		200	

Sample Location	MW-62S							
Date Collected	5/29/2003		10/2/2003		4/13/2004		4/13/2004, Duplicate	
Sampling Event	Pre-Treatment		Post-Treatment		Long-Term Monitoring		Long-Term Monitoring	
Sample Collection Method	peristaltic pump		peristaltic pump		peristaltic pump		peristaltic pump	
Analyte	Conc. (ug/L)	Qual.	Conc. (ug/L)	Qual.	Conc. (ug/L)	Qual.	Conc. (ug/L)	Qual.
TCL VOCs								
1,1,1-Trichloroethane	20	U	100	U	2	U	2	U
1,1,2,2,-Tetrachloroethane	20	U	100	U	2	U	2	U
1,1,2-Trichloroethane	20	U	100	U	2	U	2	U
1,1-Dichloroethane	20	U	100	U	2	U	2	U
1,1-Dichloroethene	20	U	100	U	2	U	2	U
1,2-Dichloroethane	20	U	100	U	2	U	2	U
1,2-Dichloropropane	20	U	100	U	2	U	2	U
2-Butanone	20	U	63	J	2		2.6	
2-Hexanone	20	U	250	U	2	U	2	U
4-Methyl-2-pentanone	20	U	100	U	2	U	2	U
Acetone	51		310		2.7	J	2.6	J
Benzene*	59		66	J	3.4		3.5	
Bromodichloromethane	20	U	100	U	2	U	2	U
Bromoform	20	U	100	U	2	U	2	U
Bromomethane	50	U	100	U	2	U	2	U
Carbon disulfide	20	U	100	U	2	U	2	U
Carbon tetrachloride	20	U	100	U	2	U	2	U
Chlorobenzene	20	U	100	U	2	U	2	U
Chloroethane	20	U	100	U	2	U	2	U
Chloroform	26		100	U	2	U	2	U
Chloromethane	20	U	100	U	2	U	2	U
1,2-Dichloroethene (total)	20	U	100	U	2	U	2	U
Cis-1,3-dichloropropene	20	U	100	U	2	U	2	U
Dibromochloromethane	20	U	100	U	2	U	2	U
Ethylbenzene*	110		790		12		12	
Methylene chloride	50	U	100	U	5	U	5	U
Methyl-tert-butyl ether	20	U	100	U	2	U	2	U
Naphthalene	89		340		15		15	
Styrene	20	U	100	U	2	U	2	U
Tetrachloroethene	20	U	100	U	2	U	2	U
Toluene*	85		230		17		17	
Trans-1,3-dichloropropene	20	U	100	U	2	U	2	U
Trichloroethene	20	U	100	U	2	U	2	U
Vinyl chloride	20	U	100	U	2	U	2	U
p/m - Xylene*	410		2000		47		48	
o-Xylene*	150		710		20		19	
Total VOCs	980		4509		119.1		119.7	
Total BTEX	814		3796		99.4		99.5	
SVOC								
2-Methylnaphthalene	29		NA		4.6		2.2	
Benzene % Reduction (from 6/2/03)			-12%		94%		94%	
Total BTEX % Reduction (from 6/2/03)			-366%		88%		88%	
Low Flow Parameters								
Temp (C)	12.2		16.2		20.8		20.8	
pH	6.25		5.98		5.32		5.32	
Spec. Conductivity (umhos/cm)	286		5809		460		460	
Turbidity (NTUs)	5.4		17.0		5.5		5.5	
D.O. (mg/l)	1.45		0.48		0.18		0.18	
ORP (mV)	-30.1		-35.7		128.9		128.9	
Flow Rate (ml/min)	170		100		180		180	

Table F-1
Groundwater Analytical Results
Site 4 ERH Remediation
Bedford NWIRP Site
Bedford, Massachusetts

Sample Location	MW-63S								MW-64S						MW-65S												IW-5		MW-66S							
Date Collected	6/2/2003		9/9/2003		10/1/2003		4/14/2004		5/30/2003		9/30/2003		4/14/2004		6/2/2003		6/30/2003		9/9/2003		9/9/2003, Duplicate		9/30/2003		4/14/2004		6/30/2003		6/30/2003		10/1/2003		10/1/2003, Duplicate		4/14/2004	
Sampling Event	Pre-Treatment		Mid-Process		Post-Treatment		Long-Term Monitoring		Pre-Treatment		Post-Treatment		Long-Term Monitoring		Pre-Treatment		Pre-Treatment		Mid-Process		Mid-Process		Post-Treatment		Long-Term Monitoring		Pre-Treatment		Pre-Treatment		Post-Treatment		Post-Treatment		Long-Term Monitoring	
Sample Collection Method	peristaltic pump		peristaltic pump		peristaltic pump		peristaltic pump		peristaltic pump		peristaltic pump		peristaltic pump		peristaltic pump		peristaltic pump		peristaltic pump		peristaltic pump		peristaltic pump		peristaltic pump		peristaltic pump		peristaltic pump		peristaltic pump		peristaltic pump		peristaltic pump	
Analyte	Conc. (ug/L)	Qual.	Conc. (ug/L)	Qual.	Conc. (ug/L)	Qual.	Conc. (ug/L)	Qual.	Conc. (ug/L)	Qual.	Conc. (ug/L)	Qual.	Conc. (ug/L)	Qual.	Conc. (ug/L)	Qual.	Conc. (ug/L)	Qual.	Conc. (ug/L)	Qual.	Conc. (ug/L)	Qual.	Conc. (ug/L)	Qual.	Conc. (ug/L)	Qual.	Conc. (ug/L)	Qual.	Conc. (ug/L)	Qual.	Conc. (ug/L)	Qual.	Conc. (ug/L)	Qual.	Conc. (ug/L)	Qual.
TCL VOCs																																				
1,1,1-Trichloroethane	100	U	10	U	20	U	2	U	40	U	40	U	2	U	100	U	100	U	20	U	20	U	10	U	2	U	20	U	4	U	10	U	10	U	2	U
1,1,2,2,-Tetrachloroethane	100	U	10	U	20	U	2	U	40	U	40	U	2	U	100	U	100	U	20	U	20	U	10	U	2	U	20	U	4	U	10	U	10	U	2	U
1,1,2-Trichloroethane	100	U	10	U	20	U	2	U	40	U	40	U	2	U	100	U	100	U	20	U	20	U	10	U	2	U	20	U	4	U	10	U	10	U	2	U
1,1-Dichloroethane	100	U	10	U	20	U	2	U	40	U	40	U	2	U	100	U	100	U	20	U	20	U	10	U	2	U	20	U	4	U	10	U	10	U	2	U
1,1-Dichloroethene	100	U	10	U	20	U	2	U	40	U	40	U	2	U	100	U	100	U	20	U	20	U	10	U	2	U	20	U	4	U	10	U	10	U	2	U
1,2-Dichloroethane	100	U	10	U	20	U	2	U	40	U	40	U	2	U	100	U	100	U	20	U	20	U	10	U	2	U	20	U	4	U	10	U	10	U	2	U
1,2-Dichloropropane	100	U	10	U	20	U	2	U	40	U	40	U	2	U	100	U	100	U	20	U	20	U	10	U	2	U	20	U	4	U	10	U	10	U	2	U
2-Butanone	75	J	250		92		11		150		460		7.5		100	U	89	J	110		100		42		6.6		39		4.8		9.8	J	9.3	J	14	
2-Hexanone	100	U	25	U	50	U	2.2		40	U	22	J	4.2		100	U	100	U	50	U	50	U	25	U	1.1	J	20	U	4	U	25	U	25	U	2	U
4-Methyl-2-pentanone	100	U	25	U	20	U	2.8		40	U	40	U	1.7	J	100	U	100	U	50	U	50	U	10	U	2	U	20	U	4	U	7.5	J	7.2	J	2	U
Acetone	220	J	2000		620		24		210		2400		13		200	J	220	J	840		710		370		16		100		18		25		23	J	5	U
Benzene*	180		10	U	20	U	26		43		32	J	4.4		320		270		18	J	14	J	6.2	J	40		360		52		32		32		91	
Bromodichloromethane	100	U	10	U	20	U	2	U	40	U	40	U	2	U	100	U	100	U	20	U	20	U	10	U	2	U	20	U	4	U	10	U	10	U	2	U
Bromoform	100	U	10	U	20	U	2	U	40	U	40	U	2	U	100	U	100	U	20	U	20	U	10	U	2	U	20	U	4	U	10	U	10	U	2	U
Bromomethane	250	U	25	U	20	U	2	U	100	U	40	U	2	U	250	U	250	U	50	U	50	U	10	U	2	U	50	U	10	U	10	U	10	U	2	U
Carbon disulfide	100	U	13		20	U	2	U	40	U	40	U	2	U	100	U	100	U	20	U	20	U	10	U	2	U	20	U	4	U	10	U	10	U	2	U
Carbon tetrachloride	100	U	10	U	20	U	2	U	40	U	40	U	2	U	100	U	100	U	20	U	20	U	10	U	2	U	20	U	4	U	10	U	10	U	2	U
Chlorobenzene	100	U	10	U	20	U	2	U	40	U	40	U	2	U	100	U	100	U	20	U	20	U	10	U	280		20	U	4	U	10	U	10	U	2	U
Chloroethane	100	U	10	U	20	U	2	U	40	U	40	U	2	U	100	U	100	U	20	U	20	U	10	U	2	U	20	U	4	U	10	U	10	U	1.6	J
Chloroform	100	U	10	U	20	U	2	U	40	U	40	U	2	U	100	U	100	U	20	U	20	U	10	U	2	U	20	U	4.1		10	U	10	U	2	U
Chloromethane	100	U	10	U	20	U	2	U	40	U	40	U	2	U	100	U	100	U	20	U	20	U	10	U	2	U	20	U	4	U	10	U	10	U	2	U
1,2-Dichloroethene (total)	100	U	10	U	20	U	6.8		40	U	40	U	2	U	100	U	100	U	20	U	20	U	10	U	4.4		20	U	4	U	10	U	10	U	2.7	
Cis-1,3-dichloropropene	100	U	10	U	20	U	2	U	40	U	40	U	2	U	100	U	100	U	20	U	20	U	10	U	2	U	20	U	4	U	10	U	10	U	2	U
Dibromochloromethane	100	U	10	U	20	U	2	U	40	U	40	U	2	U	100	U	100	U	20	U	20	U	10	U	2	U	20	U	4	U	10	U	10	U	2	U
Ethylbenzene*	1600		6.0	J	25		430		280		1000		130		1500		2300		420		370		78		2	U	800		210		26		26		240	
Methylene chloride	250	U	25	U	20	U	5	U	100	U	100	U	5		250	U	250	U	50	U	50	U	10	U	5	U	50	U	10	U	10	U	10	U	5	U
Methyl-tert-butyl ether	100	U	10	U	20	U	2	U	40	U	40	U	2	U	100	U	100	U	20	U	20	U	10	U	2	U	20	U	4	U	10	U	10	U	2	U
Naphthalene	410		11	J	21		500		360		1700		470		360		620		790		670		90		190		190		31		8.7	J	8.6	J	40	
Styrene	100	U	25	U	20	U	2	U	40	U	40	U	2	U	100	U	100	U	50	U	50	U	10	U	2	U	20	U	4	U	10	U	10	U	2	U
Tetrachloroethene	100	U	10	U	20	U	2	U	40	U	40	U	2	U	100	U	100	U	20	U	20	U	10	U	2	U	20	U	4	U	10	U	10	U	2	U
Toluene*	4400		14		27		27		920		1000		13		5900		6600		600		520		81		250		1400		24		91		86		46	
Trans-1,3-dichloropropene	100	U	10	U	20	U	2	U	40	U	40	U	2	U	100	U	100	U	20	U	20	U	10	U	2	U	20	U	4	U	10	U	10	U	2	U
Trichloroethene	100	U	10	U	20	U	1.2	J	40	U	40	U	2	U	100	U	100	U	20	U	20	U	6.9	J	5.6		16	J	5.4		6.7	J	6.3	J	3.5	
Vinyl chloride	100	U	10	U	20	U	2	U	24	J	40	U	2	U	100	U	100	U	20	U	20	U	10	U	2	U	20	U	4	U	10	U	10	U	2	U
p/m - Xylene*	8700		31		62		1300		6700		4900		1100		6200		8000		1800		1600		330		650		1800		130		260		250		190	
o-Xylene*	4200		7.0	J	24		290		4200		2600		260		2600		2900		910		780		120		400		600		43		93		90		88	
Total VOCs	19785		2332.0		871		2582		12887		14114		2002.1		17080		20999		5488		4764		1124.1		1560.2		5305		522.3		559.7		538		719.5	
Total BTEX	19080		58.0		138		2073		12143		9532		1507.4		16520		20070		3748		3284		615.2		1342		4960		459		502		484		655	
SVOC																																				
2-Methylnaphthalene	44		NA		NA		60		60		NA		76		34		80		NA		NA		NA		14		41		1.1		NA		NA		1.6	
Benzene % Reduction (from 6/2/03)			94%		89%		86%				26%		90%				16%		94%		96%		98%		88%						38%		38%		-75%	
Total BTEX % Reduction (from 6/2/03)			100%		99%		89%				22%		88%				-21%		77%		80%		96%		92%						-9%		-5%		-43%	
Low Flow Parameters																																				
Temp (C)	12.8		NA		16.8		22.5		12.0		28.5		21.0		12.1		15.0		21.8		21.8		25.5		17.9		15.2		15.2		21.4		21.4		12.3	
pH	6.16		NA		5.84		6.55		6.04		6.03		5.91		6.24		6.35		6.03		6.03		8.07		6.83		6.24		6.23		6.51		6.51		6.60	
Spec. Conductivity (umhos/cm)	290		NA		1503		472		296		658		309		241		488		414		414		1479		475		778		471		556		556		372	
Turbidity (NTUs)	32.0		NA		2.7		3.1		3.1		10.0		1.1		16.0		14.6		16.2		16.2		0.5		1.3		NR		6.5		2.8		2.8		4.4	
D.O. (mg/l)	0.65		NA		4.41		-0.64		2.69		2.60		0.29		-237.70		0.72		1.40		1.40		0.89		0.18		1.02		2.61		0.45		0.45		-1.00	
ORP (mV)	-84.5		NA		111.6		-157.1		14.0		29.6		-9.4		1.3		-30.1		70.5		70.5		-111.2		-191.3		-64.8		-123.2		5.9		5.9		-96.8	
Flow Rate (ml/min)	170		NA		100		250		200		NR		200		150		120		150		150		100		150		100		120		200		200		180	

APPENDIX G

Summary of Analytical Results – Vapor

Table G-1
Vapor Analytical Results
Site 4 Remediation Influent
(Vapor Samples Collected Using Summa Canisters)

Sample ID	Site 4 INF		Site 4 INF		VR-INFL4-081403		VR-INFL4-082203		VR-INFL4-082803		VR-INFL4-090603		VR-INFL4-091103	
Date Collected	7/31/2003		8/7/2003		8/14/2003		8/22/2003		8/28/2003		9/6/2003		9/11/2003	
Analyte (TCL VOCs)	ppbv	Qual.	ppbv	Qual.	ppbv	Qual.	ppbv	Qual.	ppbv	Qual.	ppbv	Qual.	ppbv	Qual.
1,1,1-Trichloroethane		U		U		U		U		U		U		U
1,1,2,2,-Tetrachloroethane		U		U		U		U		U		U		U
1,1,2-Trichloroethane		U		U		U		U		U		U		U
1,1-Dichloroethane		U		U		U		U		U		U		U
1,1-Dichloroethene		U		U		U		U		U		U		U
1,2-Dichloroethane		U		U		U		U		U		U		U
1,2-Dichloropropane		U		U		U		U		U		U		U
2-Butanone		U		U		U		U		U		U		U
2-Hexanone		U		U		U		U		U		U		U
4-Methyl-2-pentanone		U		U		U		U		U		U		U
Acetone		U		U		U		U		U		U	**1300**	
Benzene*	**92**		**12**		**16**		**32**		**520**		**38**		**220**	
Bromodichloromethane		U		U		U		U		U		U		U
Bromoform		U		U		U		U		U		U		U
Bromomethane		U		U		U		U		U		U		U
Carbon disulfide		U		U		U		U		U	**240**			U
Carbon tetrachloride		U		U		U		U		U		U		U
Chlorobenzene		U		U		U		U		U		U		U
Chloroethane		U		U		U		U		U		U		U
Chloroform		U		U		U		U		U		U		U
Chloromethane		U		U		U		U		U	**35**			U
Cis-1,2-Dichloroethene		U		U		U		U		U		U		U
Cis-1,3-dichloropropene		U		U		U		U		U		U		U
Dibromochloromethane		U		U		U		U		U		U		U
Ethylbenzene*	**260**		**66**		**30**		**170**		**4900**		**400**		**9700**	
Methylene chloride		U		U		U		U		U		U		U
Methyl-tert-butyl ether		U		U		U		U		U		U		U
Naphthalene		U		U		U		U		U	**160**		**7800**	
Styrene		U		U		U		U		U		U		U
Tetrachloroethene		U		U		U		U		U		U		U
Toluene*	**1600**		**330**		**140**		**650**		**13000**		**2100**		**12000**	
Trans 1,2-dichloroethene		U		U		U		U		U		U		U
Trans-1,3-dichloropropene		U		U		U		U		U		U		U
Trichloroethene		U		U		U		U		U	**50**			U
Vinyl chloride		U		U	**7.2**			U		U		U		U
p/m - Xylene*	**9200**		**3000**		**2300**		**5200**		**45000**		**6700**		**61000**	
o-Xylene*	**3600**		**1400**		**1300**		**2400**		**16000**		**2700**		**24000**	
TVO (Total VOCs)	**14752**		**4808**		**3793.2**		**8452**		**79420**		**12423**		**116020**	
Total BTEX	**14752**		**4808**		**3786**		**8452**		**79420**		**11938**		**106920**	
Tentatively Identified Compounds (TICs)														
Benzene, 1-ethyl-2-methyl-													**24000**	
Benzene, 1-ethyl-3-methyl-							**3800**						**22000**	
Benzene, 1-ethyl-4-methyl-			**2300**		**1400**						**5600**		**87000**	
Benzene, 1,2,3-trimethyl-													**32000**	
Benzene, 1,3,5-trimethyl-			**1400**								**5100**		**89000**	
Benzene, 1-methyl-3-propyl													**29000**	
Benzene, 1-ethyl-3,5-dimethyl-													**46000**	
Butane, 2-methyl-	**6400**				**2200**		**6300**		**63000**					
Pentane							**2800**							
Pentane, 2-methyl-	**15000**		**1400**		**2000**		**6200**		**120000**		**5000**		**23000**	
Pentane, 3-methyl-	**6800**				**980**		**2700**				**2500**			
Pentane, 2,3-dimethyl-	**7600**		**1600**				**2400**		**76000**		**3600**			
Pentane, 3-ethyl-	**7500**						**2700**				**4200**			
Pentane, 2,2,4-trimethyl-	**13000**						**4300**							
Pentane, 2,3,3-trimethyl-									**72000**					
Heptane											**2800**			
Heptane, 2-methyl-													**33000**	
Heptane, 4-methyl-			**1200**											
Heptane, 3-methyl-			**1100**											
Heptane, 3,4-dimethyl-			**2600**											
1-Pentene, 2-methyl-					**970**									
Cyclobutane, ethyl-					**2100**									
Cyclopentane, methyl-	**5500**								**53000**					
Hexane	**4900**								**46000**					
Hexane, 2,2-dimethyl-			**2500**										**32000**	
Hexane, 2,3-dimethyl-			**1700**											
Hexane, 2-methyl-	**8500**		**1600**		**1700**		**2400**		**62000**		**3700**			
Hexane, 3-methyl-					**1800**				**61000**					
Hexane, 2,2,5,5-tetramethyl-					**1900**									
Octane, 2,2,6-trimethyl-											**7500**			
Octane, 4-methyl-					**1700**									
Pyrrolidine	**8000**						**3800**				**5000**			
Unknown									**199000**					
Methane	**0.22%**		**0.025%**		**0.045%**		NA		NA		**0.021%**		NA	

Notes:
U = Non-detect
J = Analyte was detected below its reporting limit. The result was estimated.
NA = Not analyzed
Analyte with * indicates that it is a Contaminant of Concern (COC).

Table G-2
Vapor Analytical Results
Combined Effluent for Site 3 and Site 4 Operation
(Vapor Samples Collected Using Summa Canisters)

Sample ID	GAC EFF		GAC EFF		VR-EFFL-081403		VR-EFFL-082203		VR-EFFL-082803		VR-EFFL-090603		VR-EFFL-091103	
Date Collected	**7/31/2003**		**8/7/2003**		**8/14/2003**		**8/22/2003**		**8/28/2003**		**9/6/2003**		**9/11/2003**	
Analyte (TCL VOCs)	**ppbv**	**Qual.**	**ppbv**	**Qual.**	**ppbv**	**Qual.**	**ppbv**	**Qual.**	**ppbv**	**Qual.**	**ppbv**	**Qual.**	**ppbv**	**Qual.**
1,1,1-Trichloroethane		U		U		U	**2100**		**4700**		**5.4**		**15**	
1,1,2,2,-Tetrachloroethane		U		U		U		U		U		U		U
1,1,2-Trichloroethane		U		U		U		U		U		U		U
1,1-Dichloroethane		U		U	**6.8**		**600**		**710**			U	**26**	
1,1-Dichloroethene		U		U	**4.1**		**7200**		**9100**		**10**		**240**	
1,2-Dichloroethane		U		U		U		U		U		U		U
1,2-Dichloropropane		U		U		U		U		U		U		U
2-Butanone	**8.1**			U		U		U		U		U		U
2-Hexanone		U		U		U		U		U		U		U
4-Methyl-2-pentanone		U		U		U		U		U		U		U
Acetone	**20**		**4.0**		**3.9**			U		U	**4.2**			U
Benzene				U		U		U		U		U		U
Bromodichloromethane		U		U		U		U		U		U		U
Bromoform		U		U		U		U		U		U		U
Bromomethane		U		U		U		U		U		U		U
Carbon disulfide		U		U		U		U		U		U	**19**	
Carbon tetrachloride		U		U		U		U		U		U		U
Chlorobenzene		U		U		U		U		U		U		U
Chloroethane		U	**0.90**			U		U		U		U		U
Chloroform		U		U		U		U		U		U		U
Chloromethane		U		U		U		U		U	**7.1**		**3.2**	
Cis-1,2-Dichloroethene		U		U		U	**52**		**3900**		**13**		**55**	
Cis-1,3-dichloropropene		U		U		U		U		U		U		U
Dibromochloromethane		U		U		U		U		U		U		U
Ethylbenzene		U		U		U		U		U		U	**6.3**	
Methylene chloride		U		U	**10**			U		U		U		U
Methyl-tert-butyl ether		U		U		U		U		U		U		U
Naphthalene		U		U		U		U		U		U	**20**	
Styrene		U		U		U		U		U		U		U
Tetrachloroethene		U		U		U		U		U	**9.9**		**9.2**	
Toluene		U		U		U		U		U	**2.9**		**4.2**	
Trans 1,2-dichloroethene		U		U		U		U		U		U		U
Trans-1,3-dichloropropene		U		U		U		U		U		U		U
Trichloroethene		U		U		U		U		U	**160**		**63**	
Vinyl chloride		U	**17.0**		**28**		**42**			U		U	**23**	
p/m - Xylene		U		U		U		U	**110**			U	**43**	
o-Xylene		U		U		U		U		U		U	**18**	
TVO (Total VOCs)	**28.1**		**21.9**		**52.8**		**9994**		**18520**		**212.5**		**544.9**	
Tentatively Identified Compounds (TICs)														
Benzene, 1-ethyl-2-methyl-													**120**	
Benzene, 1,3,5-trimethyl-													**160**	
Benzene, 1-ethyl-2,4-dimethyl-													**95**	
Butane					**230**		**1400**						**82**	
Butane, 2-methyl-					**470**		**9900**		**58000**				**880**	
1-Butene					**28**									
1-Butene, 3-methyl-							**880**							
Cyclobutanone							**1100**							
Cyclopropane, ethyl-					**85**									
Cyclopropane, 1,1-dimethyl-									**6100**					
Cyclohexane													**76**	
Ethane, 1,2-dichloro-1,1,2-trifluoro-					**8.6**									
Hexane									**4500**		**32**			
Hexane, 2-methyl-											**38**			
Heptane											**32**			
Cyclopentane, methyl-							**5000**				**34**		**160**	
1-Pentene, 2-methyl-									**17000**					
2-Pentene							**1000**							
2-Pentene, (Z)-									**4800**					
2-Pentene, 4-methyl-, (Z)-									**8100**					
Pentane					**4.1**		**5500**		**24000**				**280**	
Pentane, 2-methyl-									**49000**		**78**		**100**	
Pentane, 3-methyl-							**1200**		**21000**		**40**			
Propane, 2-methyl-					**770**									
Pentane, 2,3-dimethyl-											**39**			
Pentane, 2,4-dimethyl-											**19**			
Pentane, 2,2,4-trimethyl-											**61**			
Pyrrolidine											**39**			
Unknown	**6.6**		**12**		**715.9**		**5060**		**4100**					
Methane	**0.31%**		**0.027%**		**0.036%**		NA		NA		NA		NA	

Notes:
U = Non-detect
J = Analyte was detected below its reporting limit. The result was estimated.
NA = Not analyzed
Note that effluent vapor data represent a combined vapor mass from the Site 3 pilot test and Site 4 remediation.

APPENDIX H

Waste Management Tracking Sheets

WASTE TRACKING TABLE
ERH REMEDIATION
BEDFORD NWIRP SITE
BEDFORD, MASSACHUSETTS

Waste Stream	# of Containers	Total Quantity	Ship Date	State Manifest Doc. #	Generator Manifest Doc. #	Treatment, Storage and Disposal Facility	USEPA Waste Code(s)	State Waste Code(s)	Complete Manifest Package #	Transfer Facility	Transfer Facility State Manifest Doc. #
Non-Hazardous Soil Cuttings	10 roll-off dumpsters	130.94 tons	10/20/03 - 10/23/03	N/A	00193	Waste Management of New Hampshire – Gonic, NH	N/A	N/A	N/A	N/A	N/A
Soil Cuttings Shipped for Asphalt Batching	1 roll-off dumpster	12.55 tons	10/24/03	N/A	N/A	Environmental Soil Management, Inc. – Loudon, NH	N/A	N/A	N/A	N/A	N/A
Spent Vapor-Phase Granular Activated Carbon	2 bags, 4 vessels	Approximately 8,600 lbs.	11/12/03	K003339	03339	Westates Carbon Arizona – Parker, AZ	D040, D039	N/A	1	N/A	N/A
Spent Non-Hazardous Liquid-Phase Granular Activated Carbon	3 55-gallon drums	Approximately 1,200 lbs.	11/19/03	N/A – Bill of Lading	N/A	US Filter – Avon, MA	N/A	N/A	N/A	N/A	N/A

Notes: